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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

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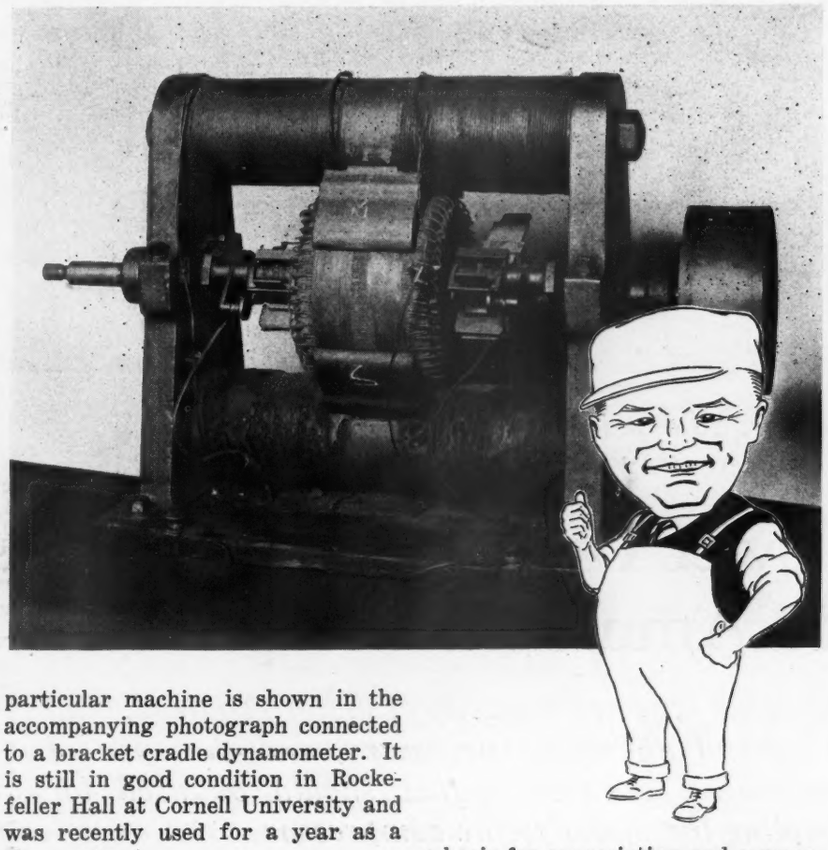
A Generator of 50 Years Ago—

and one of a very few of the first designs now available for inspection



IN THESE days of continual improvements and refinements in equipment, those of us who are 40 years of age or better either forget or do not stop to realize that all of our present electrical equipment has had its birth in crude forms during the past 50 years. We are all moving so lively these days and demand such accuracy and reliability that unless we take the time to bury ourselves in musty records now and then, there is a tendency to become blind to the service a dollar will buy today when spent for motors and generators, for instance.

Just to go back in point of time to 1875, when Thomas A. Edison was working on an unheard-of machine for generating current at constant potential, we find that there was interesting work being done on an experimental basis at other points here and abroad and one of these was the laboratories at Cornell University. Here Wm. A. Anthony, and George S. Moler, professors in the Department of Physics, were constructing a "dynamo-electric" machine, so-called in distinction from earlier "magneto-electric" machines. This was a Gramme machine similar in the main to the original Gramme design built in France, but with some added features, including movable rocker arms for the brush-holders. It was also provided with two sets of armature windings, each with its own commutator which could be used independently or connected in parallel or in series. This particular machine is shown in the accompanying photograph connected to a bracket cradle dynamometer. It is still in good condition in Rockefeller Hall at Cornell University and was recently used for a year as a shop motor.

From a construction standpoint it is of interest to note that this machine was originally wound with square wire, but this was later replaced with round wire, the cotton insulation being put on by hand. This generator, huge in size as we now know generators of like capacity, delivered 20 amp. at 150 volts with the two armature windings connected in series. It was exhibited at the Centennial Exposition in Philadelphia in 1876, at Chicago in 1893, and at St. Louis in 1904.

This particular machine is of interest today because it is available for inspection by those interested and is strictly typical of the first thinking of designers of electric generators. Moreover, it serves as a basis for appreciating and comparing the wonderful development work in electrical design that has taken place in this country in the short space of 50 years. Today a plant without a single motor is an oddity and one with a thousand or more creates little comment, for such a number of motors often requires less attention and supervision than an equivalent number of other mechanical devices.

If you are 30 years old today put this item carefully away for 25 years and it will then be a valued treasure, if you are still interested in electrical work.

Practical Pete

The synchronous motor is the accepted type of motor drive for most large ammonia compressors. This illustration shows four Electric Machinery Co. synchronous motors coupled direct to as many compressors. Manual control, as shown by the switchboard in the right background, is used for controlling these motors. The small motor-generator sets at the right furnish the excitation for the motors.

Factors to consider when selecting

Power Drive Equipment for Ammonia Compressors

including type and capacity of motor required, kind of control apparatus necessary, and the type of mechanical connection that should be used for coupling the motor to the compressor

By GORDON FOX
Electrical Engineer, Freyn Engineering Company, Chicago, Ill.

SINCE the advent of raw water ice the electric motor has been extensively adopted for driving ammonia compressors for ice manufacture. The cost of ice made by electric power is usually materially less than that made by steam or oil power. The labor is reduced. The location of the ice plant is independent of the fuel supply. The first cost of the plant is lower, and it is superior in general convenience.

Cold storage warehouses and packing houses are also large users of ammonia compressors for refrigeration, the majority of these being motor driven. Smaller installations for miscellaneous refrigerating uses are very numerous.

Refrigerating and ice plant loads are attractive to public utilities. They are steady loads of considerable magnitude, often on a 24-hr. basis. In some instances arrangements can be made to shut down for a few hours during the daily peak. The summer demand is normally heavier than the winter demand. Because of the desirable character of these loads, favorable rates are usually available.

In an ammonia refrigerating system the ammonia is drawn into the compressor and raised to a pressure of approximately 150 lb. per sq. in. The compressed gas then passes to the condenser, where the temperature is reduced below the boiling point of ammonia corresponding to the high pressure. The compressed gas, therefore, becomes a liquid. The liquid ammonia then passes to a receiver, where it is stored. From this receiver the liquid goes to the expansion coils. Upon reduction of pressure it again passes into the gaseous form, absorbing heat from its surroundings in so doing. The gas then returns again to the compressor and repeats the cycle.

Characteristics of Compressors Affecting Motor Selection

The ammonia compressor is similar in general characteristics to the air compressor. Much of the discussion relating to air compressors, which was given in the article on page 13 of the January, 1926, issue of INDUSTRIAL ENGINEER, is equally applicable to ammonia compressors. The following discussion will, therefore, be confined largely to those aspects wherein the ammonia compressor differs somewhat from the air compressor.

Ammonia compressors may be either single-stage or two-stage ma-

chines. Two-stage compression offers some advantage in higher volumetric efficiency, particularly for high-compression ratios, as during summer conditions. It reduces the loss due to "inlet heating" or expansion of the charge upon contact with the warm cylinder walls. It reduces the duty on the valves. It renders possible inter-stage cooling. However, usual water temperatures permit only partial cooling between stages. Ammonia must be used if it is desired to cool to the initial temperature. In the latter case some liquefaction occurs. The reduction in power consumption through the use of two-stage compression may range from 3 to 10 per cent, being materially less than for air compressors.

Ammonia compressors may be either single-acting or double-acting and are commonly built with one to four cylinders. Many of the larger units are of duplex design with the cylinders either vertical or horizontal, and the crank set at 90 deg.

Many ammonia compressors, particularly those of older design, employ poppet valves. The speeds of such units are particularly restricted. High-speed compressors are in reality short-stroke compressors, having higher r.p.m. but no higher piston speed. High-speed compressors have low valve lifts and commonly use plate valves. Because of the low lifts, either more or larger valves must be used than are required for slow-speed machines. Small valve areas lead to waste of power. Some of the large ammonia compressors operate at speeds as low at 72 r.p.m. From this point the different types range in speed up to about 240 r.p.m. It is desirable, from the viewpoint of both motor and flywheel, that speeds be as high as possible.

An air compressor works between approximately constant fixed pressures. The intake and discharge pressures of an ammonia compressor are subject to variation. The intake temperature and pressure are governed by the refrigeration load, and the discharge pressure is governed by the temperature of the condenser water, which determines the pressure necessary to cause liquefaction.

SELECTION of motors and auxiliary equipment for industrial applications is the subject of this series of articles by Gordon Fox. The first article of this series appeared in the January issue and discussed the application of power drive equipment to air compressors. The accompanying article supplements that discussion and shows the additional factors that must be considered in applying motors to ammonia compressors. In succeeding issues will be discussed the application of motors to other industrial equipment.

The commercial unit of refrigeration or "ton of refrigeration" is the heat required to melt 1 ton of ice. This equals 288,000 B.t.u. The expression commonly refers to the extraction of this amount of heat in a period of 24 hr.

The ice-making capacity is materially less than the refrigerating capacity. The exact value depends upon the initial temperature of the water, the final temperature of the ice and the amount of extraneous heat absorbed in process. Ordinarily from 1.8 to 2 tons of refrigeration are required to produce 1 ton of raw water ice.

Power Requirements of Ammonia Compressors

The compressor displacement required for a rated ton of refrigeration depends on the intake and discharge pressures. Ammonia compressors are commonly rated at standard conditions corresponding to an intake pressure of 15.67 lb. gage and discharge pressure of 185 lb. gage. For refrigerating duty to maintain freezing temperatures an intake pressure of about 5 lb. gage is generally maintained. For brine circulation or for ice making the intake pressure is from 15 to 20 lb. gage.

For conditions differing from rating, the capacity of a given compressor differs materially from its capacity under standard conditions. The variation of capacity with differing conditions is indicated in the table on this page. The capacity increases as the intake pressure increases in the same manner that the capacity of an air compressor increases with reduction of altitude. The capacity decreases as the discharge or condenser pressure increases.

The indicated horsepower of an ammonia compressor per ton of refrigerating capacity under standard conditions is about 1.4 to 1.5 hp.

Variation of Ammonia Compressor Capacity and Power Requirements for Different Intake and Condenser Pressures and Temperatures

Condenser Pressure and Temperature		Intake Pressures in Lb. Gage and Intake Temperatures in Deg. F.																	
		5 Lb.—17.5 Deg.			10 Lb.—8.5 Deg.			15.67 Lb.—0 Deg.			20 Lb.—5.7 Deg.			25 Lb.—11.5 Deg.			30 Lb.—16.8 Deg.		
Lb. Gage	Deg. F.	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power	Capacity	Unit Power	Resultant Power
145	82	0.66	1.11	0.74	0.85	0.94	0.80	1.07	0.80	0.86	1.24	0.71	0.88	1.44	0.63	0.91	1.63	0.56	0.92
165	89	0.64	1.23	0.79	0.83	1.04	0.87	1.03	0.90	0.93	1.20	0.80	0.97	1.34	0.72	1.00	1.58	0.65	1.02
185	95.5	0.62	1.34	0.84	0.80	1.15	0.92	1.00	1.00	1.00	1.16	0.89	1.04	1.35	0.80	1.08	1.53	0.73	1.11
205	101.4	0.60	1.47	0.88	0.77	1.26	0.98	0.97	1.09	1.06	1.12	0.99	1.11	1.31	0.89	1.16	1.48	0.85	1.26

This table gives the ratio of refrigerating capacity, ratio of horsepower per ton of refrigeration, and ratio of resultant horsepower required, for different sets of operating conditions as compared with standard conditions of intake pressure of 15.67 lb., intake temperature of 0 deg. F., condenser pressure of 185 lb., and condenser temperature of 95.5 deg. F.

The columns marked Capacity give the ratio of refrigerating capacity of the ammonia compressor; the columns marked Unit Power give the ratio of horsepower required per ton of refrigeration; and the columns marked Resultant Power give the ratio of resultant horsepower required by the compressor.

for single-acting compressors and 1.6 to 1.7 hp. for double-acting compressors. For conditions other than standard the horsepower per ton of refrigeration varies both because of the change in the amount of ammonia to be compressed and also because of the differing range of pressures between which the machine is working. As the intake pressure increases the amount of ammonia required per ton of refrigeration decreases and the horsepower per unit of value compressed also decreases. As the condenser pressure increases the amount of ammonia required per ton of refrigeration increases and the unit power also increases. The horsepower per unit of refrigeration is lowest with high intake pressures and low condenser pressures. Inasmuch as the capacity of a given compressor varies at the same time that the horsepower per unit of refrigeration varies, the resulting power requirement of the compressor depends upon both the capacity and the unit power consumption for each set of conditions and does not vary so widely, as will be seen from the accompanying table. A given ammonia compressor driven at a constant speed will take the least horsepower when operating with low intake pressure and low discharge pressure. It will take the most horsepower when operating with high intake pressure and high discharge pressure.

The graph on page 109 shows average values of indicated horsepower per ton of refrigeration at several intake pressures and over the range of discharge pressures.

The motor capacity should be about 125 per cent of the indicated horsepower for the larger machines and from 130 to 150 per cent for the smaller machines, rated at 10 tons or under, based on maximum load conditions with respect to the range of pressures to be expected. Unless otherwise stated it is customary to consider an intake pressure of 30 lb. and a discharge pressure of 215 lb. as representing the maximum load condition. As contrasted with the air compressor, which cannot be overloaded, the ammonia compressor may assume an abnormal load if the intake and discharge pressures become abnormally high. The motor is, therefore, subject to possible overloads.

The power required for ice making is subject to rather wide variation. Some plants operating at capacity under favorable conditions produce a ton of ice with 40 to 50 kw-hr., while the consumption may reach 80 to 90 kw.-hr. per ton. These figures are inclusive of auxiliaries. Many factors of design and operation may contribute to high power consumption. Among these may be mentioned insufficient condenser capacity, dirty condensers, non-condensible gases in the system, insufficient or warm condensing water, insufficient cooling coils, necessitating low inlet pressures, lack of proper heat insulation, leaky pistons, and insufficient ammonia charge. As the cost of power is a predominant factor in the cost of ice manufacture it is essential that conditions favorable to economy be maintained. The use of metered electric power is of great assistance to this end.

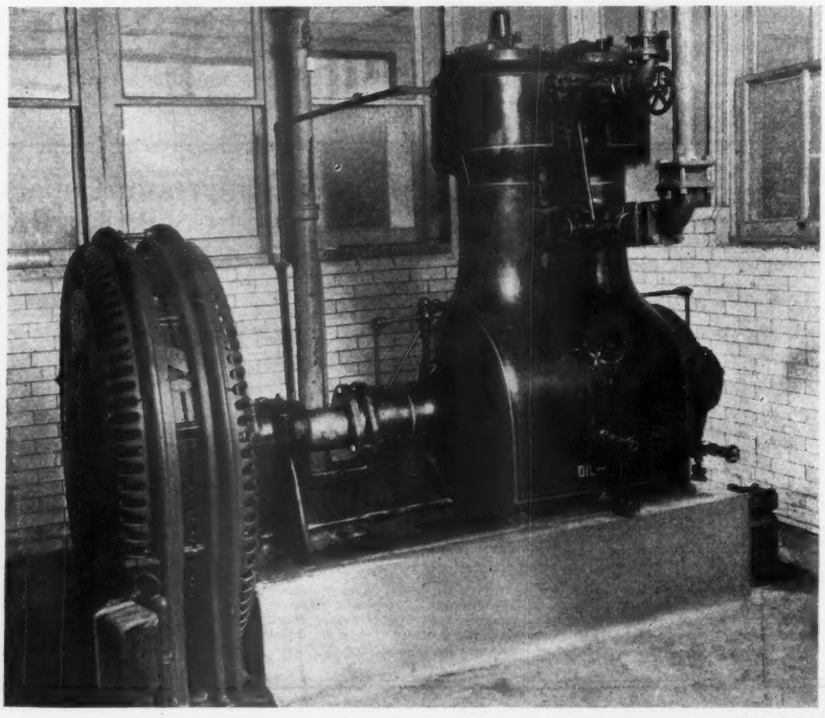
Methods of Varying Output of Ammonia Compressors

It will be observed from the table on page 107 that the capacity of a given ammonia compressor varies with changes of system conditions. In refrigerating service the amount of cooling effect required will vary. In ice manufacture it is also necessary to adjust the output to the demand. Several methods are in vogue to meet this need of variation of output. In many refrigerating plants, notably in the case of small and moderate-sized installations using direct-current motors, some form of speed adjustment is employed. In the larger refrigerating plants and in ice-making plants it is more common practice to install several compressor units, often of differing capacities, and to operate suitable combinations to meet the requirements, these units being driven at constant speed. In the case of duplex compressors it is sometimes the practice to disconnect one-half of the unit to halve the capacity. This practice is not desirable, from an electrical viewpoint, because of the greater torque pulsation, the requirement of greater flywheel effect and greater current pulsation. Some compressors provide for operation at partial capacities through use of variable clearance pockets. These permit reduction to about half capacity. They are hand operated. Ammonia compressors are not commonly provided with automatic and complete unloading devices corresponding to air compressor practice.

In general, the same types of motors are adapted to both air and ammonia compressors. Alternating-current drives predominate, but there are many direct-current drives also. The synchronous motor is the accepted type for most large

No motor bearings are required in this installation.

The rotor of this Electric Machinery Co. 75-hp., 180-r.p.m., synchronous motor is pressed directly on to the compressor crank shaft, the crank shaft bearings being large enough to carry the additional load. This does away with the necessity of an outboard bearing on the motor and makes the motor very accessible.



units, and for many of the smaller units. Its preference is dictated by the same advantages that apply to its application for driving air compressors. These motors are more commonly direct-connected. Induction motors are often used for driving ammonia compressors of small and medium size. This type of motor is not practical at very low speeds so that short-center belt, gear, or chain drives are employed to obtain the desired speed reduction. The wound-rotor induction motor is usually selected. This choice may be dictated by the desire to vary the speed or by the superior starting performance of the wound-rotor motor, or by both considerations. When the compressor is started unloaded, the squirrel-cage motor may be satisfactory in starting performance. The wound-rotor motor is inefficient at reduced speeds and is, therefore, open to objection. The brush-shifting type of polyphase commutator motor is well suited to the requirements of ammonia compressor service where speed adjustment is desired. This type of motor is also unavailable at compressor speeds so that direct connection to it is not possible. As this type of motor is relatively costly its selection must be justifiable on the basis of power economy in the event of extensive operation at reduced speeds.

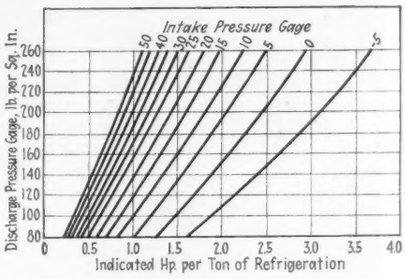
For some of the smaller automatic refrigerating equipments it is desirable that the motor be able to start the compressor without using a by-pass for unloading. The double squirrel-cage induction motor, connected directly across full voltage in starting, has been successfully applied to this service.

Where direct current is available the compound-wound motor is given preference for constant-speed service because of its superior starting performances and its better operation with fluctuating voltage. Many adjustable-speed, shunt motors are applied to compressors used for refrigerating duty. A speed ratio of 2 to 1 or thereabouts is common. These motors are commonly arranged for belt, gear, or chain drive, in which case standard motors may be utilized. However, special, slow-speed motors for direct connection are sometimes used.

One respect in which the ammonia compressor differs from the air compressor, from the motor application standpoint, is the occasional requirement of speed adjustment for refrigerating duty. This leads to the use of motors providing speed control, as contrasted with the almost universal use of constant-speed drives for air compressors.

Selection of Type of Drive Connection

In methods of mechanical connection to the motor the ammonia compressor parallels closely the air compressor. The smaller units are commonly chain or belt driven, the short-center belt drive with idler pulley being popular. This arrangement permits the use of standard,



The power requirements of ammonia compressors vary with the intake and discharge pressures.

Each curve is for a different intake pressure. Follow the curve of the given intake pressure until it intersects the abscissa or horizontal line representing the given discharge pressure, then read down to the bottom scale to obtain the indicated horsepower per ton of refrigeration when working between the given intake and discharge pressures.

moderate speed motors. Belt and rope drives were originally employed with synchronous motors. Later it became the practice to couple a self-contained synchronous motor, provided with bedplate and pedestal bearings. This type of installation is shown in the illustration at top of page 106. It is now the prevailing practice to use engine-type motors having the rotor mounted directly on the compressor shaft. In some cases an outboard motor bearing is used but this may well be omitted as shown in the illustration on page 108. In the case of duplex compressors the motor is commonly located between the halves, sufficient space being provided to permit the stator to be shifted to afford access to the windings. Some motors of this type are built with the rotor split in halves, the rims being clamped together with shrink links and the hubs bolted together during erection. This practice avoids the necessity of pressing the rotor on the shaft at either the compressor factory or the motor factory.

In the case of direct-connected, synchronous-motor-driven units it is a common practice to incorporate the flywheel effect in the rotor of the motor. Due to the lower speeds of ammonia compressors, considerably more flywheel effect is required than for air compressors. The flywheel effect demanded increases very rapidly as the speed is reduced. Duplex, single-acting compressors require much more flywheel effect than duplex double-acting compressors to restrict the current fluctuation within the prescribed limits. If a duplex unit is to operate with one cylinder disconnected, and also when the cylinders of a duplex unit work on different systems with differing pressures, additional flywheel effect is required.

Some installations have been made in which two enclosed vertical type, self-contained compressors have been set with their shafts end to end, both units being driven by a single motor whose split rotor is clamped over the two shaft ends forming a coupling between units with cranks at 90 deg. This permits the use of a motor of twice the horsepower of a single compressor but having the same speed as the smaller motor for a single compressor would have. As contrasted with two separate units this arrangement gives the advantage of multiple cylinders having a smoother torque diagram, allowing use of a small flywheel and minimizing the current fluctuation when desired. The motor may be shifted and either compressor driven singly, but with increased fluctuation of current.

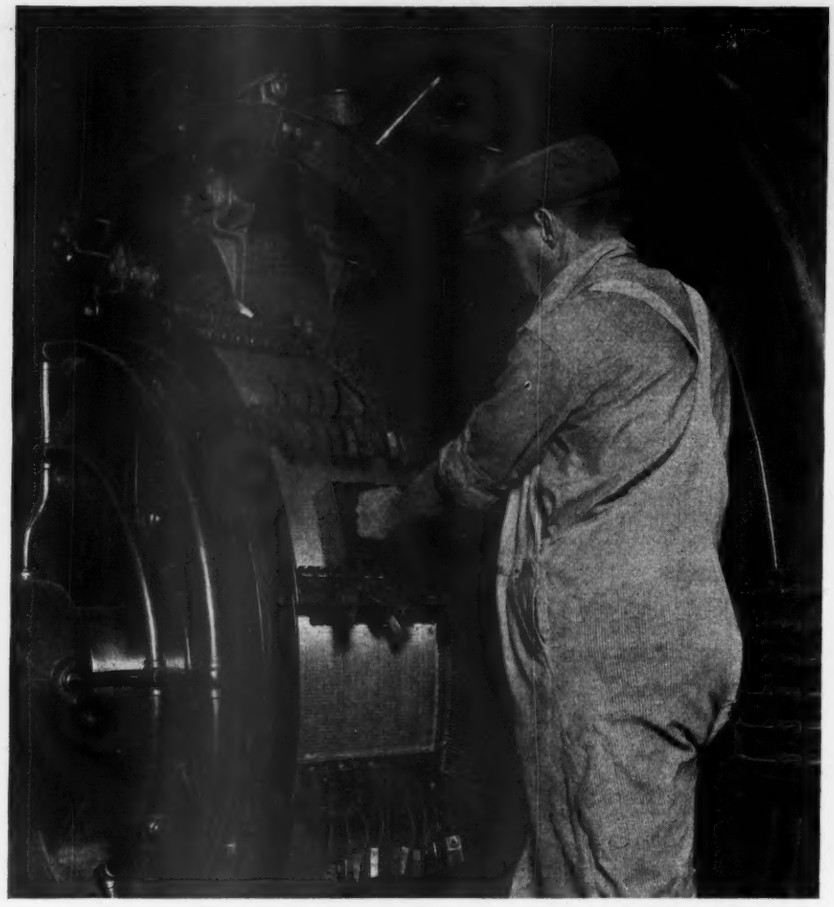
The starting duty is more severe with ammonia compressors than with air compressors. Ammonia compressors cannot be unloaded in the same manner as air compressors but the cylinders can be by-passed. Even with a liberal by-pass the unloading is not as complete as that of an air compressor. The by-pass is commonly hand controlled. If the by-pass connection is not liberal in size the starting load may be high. The slower-speed motors used for ammonia compressors naturally develop less starting and pull-in torques than those of equivalent horsepower used for driving air compressors. The larger flywheels increase the starting torque required and render it more difficult to develop sufficient pull-in torque. Both the starting torque and the pull-in torque of the great majority of modern ammonia compressors fall within the range of 15 to 35 per cent of full-load torque.

COMMUTATORS perform a very important function and must be given a certain amount of skilled attention in order to keep them in proper condition and avoid operating troubles that are expensive and annoying. In this article Mr. Weber describes some of the methods and devices which he used years ago in taking care of the commutators on early designs of generators and motors, and contrasts them with modern practices and equipment.

Reminiscences of an old-timer on

Development and Use of Commutator Stones

with pointers on how to employ them effectively to improve commutation and keep commutators in good condition



As related by
WILLIAM L. WEBER
Manager, Acme Abrasive Co., Chicago, Ill.
In an interview with
Practical Pete

IN THESE days of specialized equipment that is as nearly perfect as highly-skilled designers with years of experience behind them can make it, it is interesting to talk over old times with some one whose memory goes back to the days when all electrical equipment was new and its actions more or less of a mystery. The services of factory experts were not available within a few hours, as they are now, and there were few, if any, instruction books and precedents to follow when trouble developed. All that a fellow could do was use his wits and trust to luck that they would show him what to do, and how to do it.

A few days ago I had the pleasure of talking with the old friend whose name appears at the beginning of this article and who has been working with motors and generators and all kinds of electrical equipment since some of us were in our cradles —or before then. We discussed many things; finally the conversation turned to commutators and how to care for them—always an important and interesting subject.

"You know," he said, "that back in the 80's we thought that a commutator on a 500-light dynamo was something tremendously large. It is easy to imagine myself back in the first central station of the Chicago Edison Co., hopping about between two 10-in. belts, which were driven by the two flywheel pulleys of a high-speed engine and operated two Edison dynamos with gauze wire brushes. I well remember what terror seized me when those 'chocolate brown' commutators suddenly presented a ring of clean, raw copper, caused by the copper brushes starting to cut. How I rushed for a piece of sandpaper and nursed that ring by massaging the commutator with the sandpaper and with tallow or some other mysterious lotion in order to get it back again to that much desired 'chocolate brown'!

"When I left that job and commenced to work for the Thompson-Houston Electric Co., in Chicago, whose shops were where the Peoples Gas Building now stands, I was confronted with about the same commutator difficulties as I had with those multi-numbered and elevated polepiece dynamos which I had just left. You remember the Edison dynamos, with the high polepieces, the small-diameter armature, and the impressive-looking 'main switch' on the top of it, right over the brushes, don't you? Well, now my new pets were called the 'Type L. D.' Thompson-Houston machines and while their armatures were spherical and larger, and the frames were horizontal, still the chocolate brown on the commutator was just as difficult to maintain. Turning a commutator was a job, as it was about 10 in. in diameter and about 12 in. in width. The armature had to be removed from the dynamo and placed between centers in a lathe, and every time it had to be done it was easy to hear the Prophets advise that this business was 'hokum' and would not last long.

"There was one elderly man in that shop for whom I had a great deal of respect. He was familiarly called 'Archie Demond,' and only a few months ago passed on into the Great Beyond.

"One day I was sent out on a trouble job which turned out to be a scored commutator and after looking it over and returning to the shop for instructions, 'Archie' told me to get a piece of grindstone, run that dynamo and grind the commutator as smooth as I could until the chain gang could bring in the armature. I did so and, after a number of hours' work, produced a commutator surface that was fine and dandy. This achievement was looked upon as quite original until a man came from Lynn, Mass., and confided to us that we were doing nothing original at all. He had been doing this same thing for nearly a year."

"News travels faster than that, now," I said.

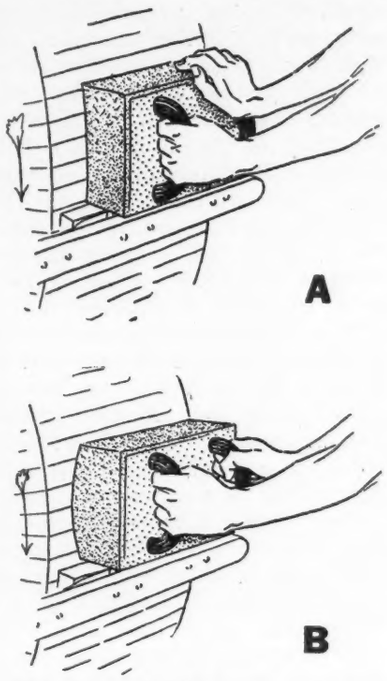
"Yes," he replied, "Can you imagine one branch of a company doing something for a year before the other branch of the same company hears of it—today?

"Something important happened about this time. A gauze wire brush with a few silver tubes running through it, was imported from Germany. The idea was that the silver tubes allowed air to pass through the brush to keep it cool, and at the same time afforded more rigidity than was obtainable in either the gauze or copper-leaf brush. It was represented that this brush would absolutely prevent cutting the commutator and retain that chocolate brown so much sought after. It did help some. Why, I do not know.

"Again something important happened. A Boston firm of grindstone quarrymen presented a natural stone, cut into a rectangular shape, to be used in place of sandpaper for grinding commutators. With this stone it was possible to grind about 1/32 in. off a commutator with an 8-in. face and the same diameter, in a day. It was looked upon as a great thing. Much was said about the special grit in this stone, and the particular kind of a stone it was, and the particular place where it was supposed to be deposited by the peculiar quip of Dame Nature.

"Then came another English product, supposed to be found in some 'Shire' on the other side. I had one of these in my tool kit and I remember that at one time I lost my watch and the commutator stone at about the same time, with the result that my grieving was directed entirely to the loss of the stone.

"As you know, commutation was not developed to its present-day degree of perfection until someone discovered a method of tapering off the abrupt magnetic break between the poles of a generator by interposing between the polepieces another set of magnets which were called interpoles. This was a great step toward sparkless commutation. It reduced the number of times we had to smooth up the commutator with either a stone, or a large wooden saddle with a leather cradle on which were bolted a number of layers of sandpaper; this was used by two men, one at each end of the device, pressing down on the commutator while it rotated. As one layer of the sandpaper became worn out it was torn off and the next, fresh layer came into play. Would you believe it, I actually saw this operation less than a year ago in a central station in a small town in New York!



This shows, A, the proper way to hold a commutator stone on the face of a commutator and, B, the wrong way.

If the stone is held by the handles, as in *B*, it will have a tendency to rock. As a result, the upper and lower edges of the stone will be rapidly worn away, producing a convex surface.

"Then came another step — the development of the graphite carbon brush. This was a real move because it actually lubricated the commutator while it was in service. Today there are many who still believe that with the graphite brush we have to maintain that 'chocolate' color, when in realty it is a glazed surface, which in itself is an imposed resistance between the brush and the commutator bar, and should not be there at all. The heat which we once tried to dissipate with the tubular German gauze brush is caused by the very same chocolate brown color. To demonstrate this to yourself, let that condition develop on the commutator of your automobile generator and it will quit generating. Another vivid demonstration is to remove the glaze on a d.c. generator commutator, without disturbing the field resistance setting, and note the voltage increase on the switchboard voltmeter. Note also that the commutator will operate at a lower temperature.

"To realize fully the importance of this, count the number of bars between brushes, multiply this by the r.p.m., and see how small a fraction of a second each bar is in contact with the brush.

"Some adventurous person thought that if natural sandstone would serve as a cutting stone for removing copper from commutator bars, why not use the harder, manufactured stone made of emery? It was tried, and with poor results, because in the first place the emery contained metallic particles and was itself a conductor of current; the small particles lodged between the bars, embedded themselves in the mica, and caused short-circuits. Besides, nothing along the lines of a satisfactory 'bond' with which to hold the particles together, had been developed.

"Some years later, in the production of aluminum, by melting bauxite clay in an electric furnace a sort of clinker was accidentally produced through some misadventure of the process; this clinker was looked upon as a most undesirable result of an otherwise good purpose. Later this clinker was found to be much harder than the emery that was being brought all the way from Turkey and, not only could it be controlled as to hardness and crystal form, but it was tougher and less of a conductor than the best emery mined. We now have various forms of this clinker crushed to different sizes of grains and known by numberless trade names, each variety having its own peculiarities.

"Wheels were made with various kinds and with various mixtures of the various kinds, bonded together with a thousand or more combinations of bonds. Among the more common bonds are shellac, silicate of soda, infusorial earths, and the like, fired in ovens at various temperatures and resulting in wheels of

different tensile strength for various speeds and for cutting numberless kinds of materials such as iron, steel, brass, copper, rubber, paper, etc. The numbers and letters found on a wheel, signifying the manufacturer's recipe for the particular mixture and process employed in making that wheel, are closely guarded as his business secret, and there are several millions of them. There is no business today with as little recorded information relative to it as the compounding and manufacture of grinding wheels, razor hones and the like.

"Several types of machines have been designed for grinding commutators with a grinding wheel while the commutator is rotating at its regular speed, with the idea of thus obtaining a surface that is as true as it is possible to obtain under working conditions, remembering the short period of time that each brush is in contact with each bar.

"It remained for someone to think of developing a manufactured grinding block which could be used in a stationary position for grinding the commutator face while it is turning at full speed, thus keeping the bars true after being finished. Taking advantage of the hard, sharp manufactured grain, and experimenting with a bond that would suit the purpose, have resulted in stones which are today capable of removing as much copper from the commutator face in 30 min. as could be done with a natural stone in a day, or more. Where a commutator has become ridged between brushes, or where flat spots have developed, it is now possible to resurface satisfactorily in much less time than required by turning and the final result is superior because the work is accomplished while under full speed."

"In your experience, what are some of the difficulties that users have encountered with commutator stones, and how can they overcome them?" I asked.

"Well," he answered, "objections have been registered by some plant operators to the effect that a commutator could not possibly be trued up with any of the several artificial stones, held to the face by hand. On the face of it this attitude seems reasonable, but when it is remembered that the process is, although old as stated, practically a new way to do the job, those who use a stone should consult someone who has had experience with it, before attempting to condemn it. Where flat spots have been developed it will be found that when using a commutator stone which has a sufficiently large face area, these spots will be 'bridged' because of the rigid nature of the stone, and only the high parts of the commutator will be ground off until sufficient copper is removed to permit the stone to reach the lowermost surface. The mistake has often been made of using a stone too small for the job, and thus really making the condition worse by grinding the flat spots more flat. Some manufacturers of these stones make them with the face of the stone concaved so that the low spots are not ground any deeper while the stone is wearing its grinding face to the curvature of the commutator.

"The surface speed at which the grinding is to be done has much to do with the coarseness or fineness of the stone used. A stone of this kind which seems to give good satisfaction at a speed of 5,000 linear ft. per min. would wear away faster at a linear speed of 1,000 ft. per min. The 'hogging cut' should be done with a coarse stone, and the 'finishing cut' with a fine one. If a certain cutting stone does nice work with comparatively low stone loss at a certain linear speed, and it wears away too fast at some other speed, or it 'clogs' copper at some other speed, the particular make of stone should not be condemned. To explain what I mean, I will mention the experience which many have had with a grinding wheel. A certain wheel is bought and placed in the grinder. It does the work splendidly. Later the wheel seems to have become 'soft' and wears away quite rapidly. If the r.p.m. of the wheel is increased to the point where the surface speed is the same as it was when new, it will again behave as it did at first. Now here is where the commutator stone manufacturer has his problem; he must produce a few different 'grades' which will serve over a wide range of speed. If the user of commutator stones has had trouble and will take the time to make a complaint and give the facts in the case to the manufacturer, the latter will, if responsible, immediately take back the stone complained of, and replace it with one that will do what is expected of it."

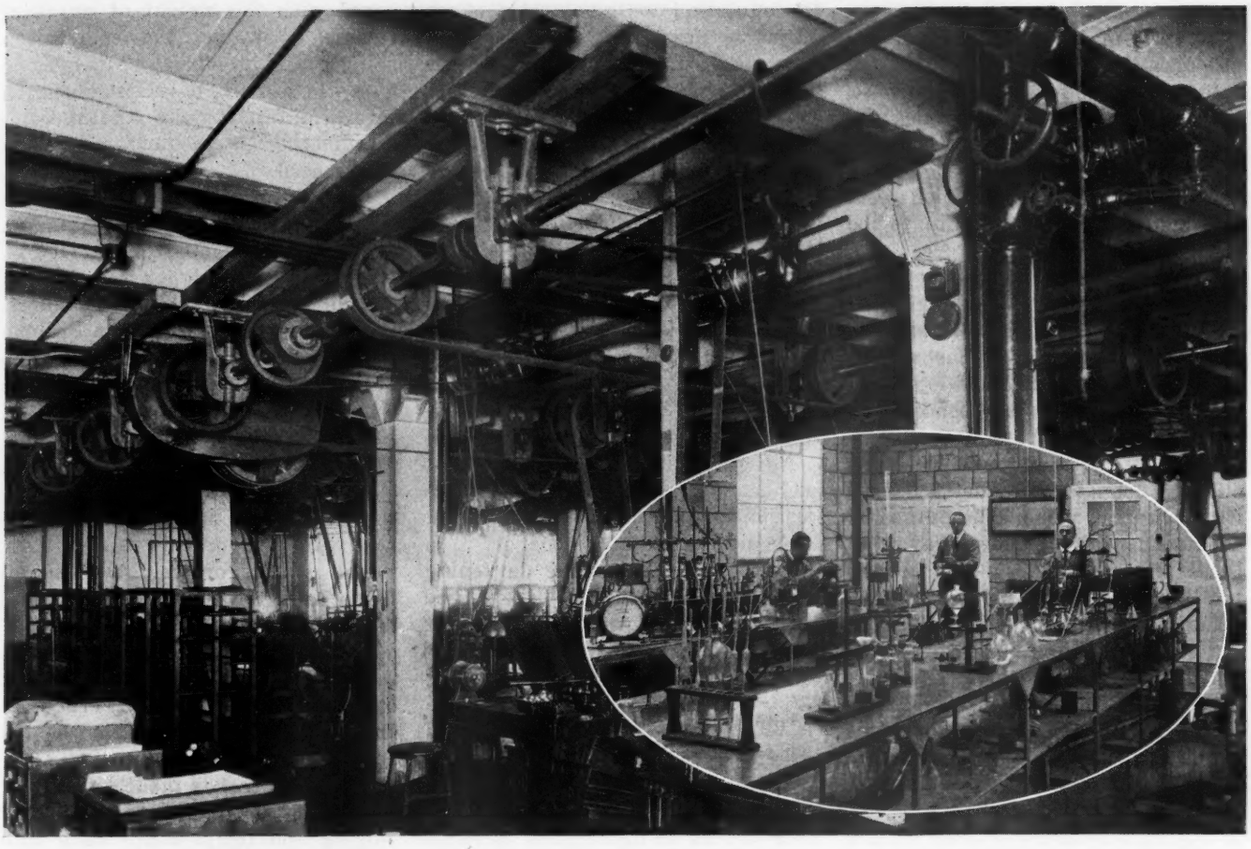
"What do you recommend should be done with a commutator that is out of round?" I asked.

"Where a commutator is worn elliptical or egg-shaped, it may be trued up with a stone by bolting a shelf rigidly to the brush rigging or frame on the down-running side of the machine; the shelf should be made of 2-in. plank and placed within ⅛ in. of the commutator. Now lay the stone on the shelf, hold it in position by hand, and allow the commutator to 'swipe' it at each revolution, moving the stone sidewise occasionally as a wood turner moves his chisel, only much slower. I have trued up commutators 8 ft. in diameter and 30 in. in width in this manner much more satisfactorily and a great deal quicker than could have been done by turning. After getting the commutator trued up, the finish grinding may be done free-handed.

"The manufacturer will advise what grades are required if the user will give the speed and size of the commutator and the width and clearance between brushes. Very small commutators are more easily removed and trued up in a lathe, but they may be maintained in good condition if a stone of medium grade is used in place of sandpaper; besides, the stone cost will be less than the cost of sandpaper. Collector rings, either of bronze, brass, iron or steel may readily be trued up with stones and the work is accomplished quite rapidly. The glassy, hard surface developed on collector rings can immediately be removed with any one of the several makes of stones.

"Here is something else that is worth considering from an efficiency standpoint; if the glaze is not allowed to form on a commutator and a high polish is maintained instead, the commutator and brush sets will operate much cooler. On a.c. motors of the slip-ring type, such as are used on elevators, if the glaze is replaced by a polish, the inrush of current will be reduced considerably and the time of acceleration also reduced, which results in a saving of current.

"Any of the various makes of so-called commutator stones should be kept well wrapped up when not in use, so that no oil or water will get on them. To look at them they do not seem to require any care in keeping, but many dollars' worth of them have been ruined by improper storage between the times they are used. They differ much from grinding wheels and the ordinary, so-called grinding blocks. Their production is the outcome of specialized study and their uses are many and varied."



The satisfactory solution of bearing problems in industry requires the use of a reliable lubricant.

Interruptions to service, which may be due to the failure of a bearing because of improper or inadequate lubrication, will cause far more loss than the cost of a lubricant selected for the work and its proper application. This industrial view was taken at the Addressograph Company, Chicago, Ill. The view of the laboratory and other illustrations in this article were supplied by the Vacuum Oil Co., New York, N. Y.

Specifications for Oil and Grease Lubricants

which includes a brief, non-technical discussion of the various characteristics that affect their application and lubricating value

By FRANK E. GOODING

Associate Editor, Industrial Engineer

TO THE average industrial operating man a discussion of the specifications and tests of lubricants leaves him with a smattering of statements and terms which he often understands vaguely. The purpose of this article is to clarify some of these ideas, explain the terminology, and indicate in a general way how the various qualities affect lubricating value.

The average industrial plant does not have the facilities for making oil tests. Plants with chemical laboratories under the direction of a trained chemist can make such tests, provided they buy or contain the special oil-testing apparatus which is required. Standard methods of making tests in this country follow the procedure specified by the American Society for Testing Materials and commonly called the A. S. T. M. tests. Specifications or results of tests can be made comparable only when based on the same standard procedure.

There are many characteristics of lubricants which might be described and many tests made to determine the nature and usefulness of lubricating oils. It is doubtful, however, if after making all these tests of an oil, the knowledge gained by an operating man would be very useful in determining the correct grade of lubricant to use for any given practical purpose.

One of the most important qualities of an oil, which determines its lubricating value, is its so-called "oiliness," or the ability to cling to a metallic surface. This quality is of great importance in that it assists in the retention of the oil within the bearing and also causes it to adhere to the rotating shaft firmly enough to be carried through between the shaft and its bearing. Without oiliness the pressure would squeeze the oil out from between the shaft and its bearing and leave a dry, metal-to-metal contact. Also, the oiliness of a lubricant affects the quality of retaining the oil on a stationary bearing so that it will not be dry when it starts up. Up to the present, however, there are no standard A. S. T. M. tests for determining oiliness. Many men attempt to estimate this quality of a lubricant by rubbing the oil between the thumb and finger. Even experienced lubricating engineers cannot rely upon the assumptions made

on the results of such crude tests.

In spite of the fact that tests do not always definitely determine the value of an oil for a given purpose, it would be well if everyone who has to do with the purchase and use of lubricants and lubricating oils knew what the more common tests are and what emphasis is to be placed on each.

For example, it is decidedly to the purchaser's interest when buying oil to know that in a great many instances such considerations as fire and flash tests of the oil he is buying are of very little consequence; that the specific gravity is not of vital importance; or that the color of the oil does not add to or detract from its lubricating value. The purchaser should know in a general way what these tests signify, so that he will not buy oil under the cloak of a technical barrage.

The *color* of lubricating oils, which are refined for many purposes, is given special attention only in the case of a very few lubricants. These lubricants may be confined to the "bleached" products which are repeatedly filtered for the purpose of providing a stainless product for use in textile work or similar industries where it might come in contact with the goods and cause damage. Generally, after an oil has been in use it picks up enough impurities so that the colorless qualities of the original oil are of little consequence. In the end, oil is purchased for use and not for looks. Color, however, does indicate to a certain extent the degree of refinement, neutralization and filtering. If an oil does not have a stable color after standing it may indicate that it is poorly refined. It may, on the other hand, indicate that the container was not clean when the oil was placed in it.

Although color is determined by the use of a tintometer by which the comparative color values are set down numerically, little or no importance can be given to these figures in determining the value and correctness of an oil for a purpose.

In connection with the color of an oil, it is interesting to note, however, that the darker the oil the higher is the number denoting its color characteristics.

It is generally thought that the coloring matter in oil is nothing more than unsaturated hydrocarbons which are susceptible to decomposition under heat. Black oils or very dark oils naturally contain more of the unsaturated hydrocarbons than the filtered oils and are, therefore, not so capable of withstanding high temperatures and severe service as are the highly-refined and specially-treated oils.

All oils when subjected to heat, such as turbine oils or internal-combustion engine oils, oxidize more or less and immediately change to a darker color. This mere darkening of the oil must not be interpreted as a breaking down of the oil nor as a diminishing of its practical lubricating value.

Gravity Does Not Determine Lubricating Value

The *gravity* of an oil is another specification which is sometimes over-sold as to its relation to lubrication. The purchaser should always bear in mind that he is purchasing oils, not to match a set of figures denoting the physical characteristics of the oil, but for the service value of the oil. The gravity of the oil is something that is secondary and is usually a result rather than a predetermined factor. Refiners do not produce oil just for the purpose of displaying figures denoting its gravity.

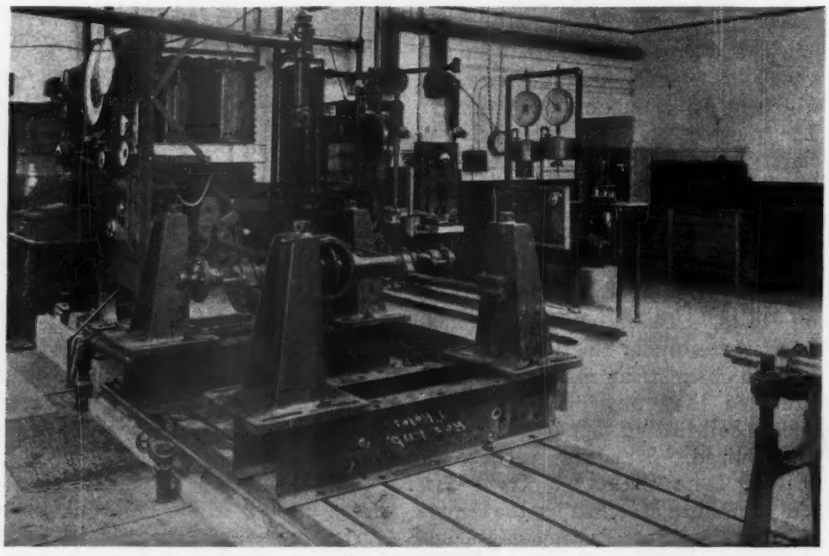
Specific gravity of an oil is the weight of a volume of that oil compared with the weight of an equal volume of water, the comparison being made at 60 deg. F. Specific gravity may be determined in several different ways; the hydrometer method is the one most commonly used.

Beaume gravity is an arbitrary scale giving direct readings in degrees which denote the density of the liquid; the higher the number on the scale the lighter the oil is. For example, an oil having a Beaume reading of 24 deg. has a specific gravity of 0.9091, which means that the weight of a gallon of that particular oil is only a trifle more than 0.9 that of a gallon of water. Most oils are lighter than water, although there are a few heavy residual products which violate this rule.

The gravity or weight of an oil is not a determining factor of its lubricating value. Practically the only value this test has is to assist in determining, in conjunction with other tests, the type of crude oil from which the lubricant was extracted.

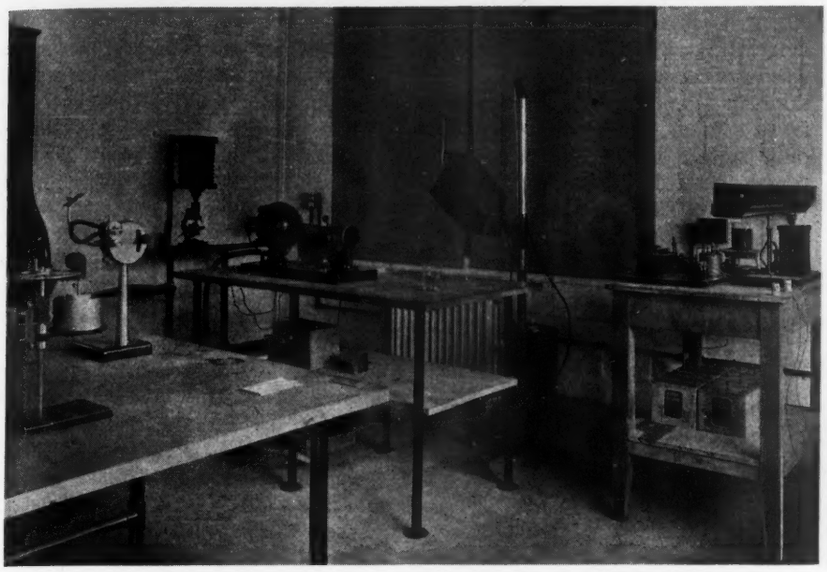
The *flash test* is made by putting a quantity of oil into a vessel and raising the temperature at a uniform rate. The temperature of the oil in the vessel is carefully noted at intervals just before applying a test flame to the vapors arising from the heated oil. The lowest temperature at which the oil vapors "flash" momentarily on the application of the flame, is the flash point of the oil. This flash point is denoted in degrees Fahrenheit or Centigrade, as the custom may demand.

The test may be made in an open cup or in a closed cup. The flash point resulting from the closed-cup



Most of the advance in lubrication practice has been due to the studies made on automobile bearings.

This view shows a dynomometer test. The study of the use of lubricants by such laboratory tests, the results of which are checked against practical operation, has given lubrication engineers a much better knowledge of what friction is, how it may be reduced, and the effect of oils of different characteristics under various operating conditions. Similar studies and investigations have been made in industrial lubrication problems.



Another section of the testing laboratory where oil problems are studied.

Standard tests are established by the American Society for Testing Materials for determining the various characteristics of oils. Many of these tests require special apparatus and considerable care and experience to get reliable results. Industrial plants which desire to test their oils and do not have a laboratory and trained chemist, may have their tests made at commercial laboratories.

test, however, is considerably lower than that of the open-cup test because the closed cup prevents the escape of the oil vapors, and a combustible mixture of air and oil vapor is produced at a lower temperature than in the open cup.

The minimum flash point of lubricating oils is about 300 deg. F. for the lightest grades. With increasing viscosity the flash point rises and in the residual oils may be as high as 600 or 700 deg. F. The lubrication of high-pressure air compressors and steam cylinders using superheated steam is about the only type of industrial work in which the flash point is of any consequence. However, most flash trouble in air compressors can be traced to too much lubrication rather than a low flash point. Incidentally, the flash point is also important in the case of tempering and transformer oils, although these applications do not come under the head of lubrication problems.

The *fire test* is conducted in the same way as the flash test; the heating of the oil is continued until the vapors from the heated oil will not only "flash" but continue to burn when the flame is removed. The minimum temperature at which the oil ignites and continues to burn is the fire point of the oil. This point is always higher than the flash point.

The flash and fire tests of any good grade of lubricating oil are sufficiently high for the work for which the particular manufacturer recommends the product. Flash and fire tests are of value in the lighter oils, such as kerosene, none of which is suitable for use as a lubricant.

The *pour test* of an oil signifies the lowest temperature at which the oil will flow or pour out of a container. The greatest care should be taken in arriving at a result in a pour test as it is quite easy to obtain several different readings for the same oil.

The *cold test* of an oil is the temperature at which the oil congeals and refuses to flow. This temperature is usually a few degrees lower than the pour test. The two tests are sometimes spoken of interchangeably, but this is erroneous as there is a distinct difference between the pour test and the cold test. An oil that has a pour test of 10 deg. F. might have a cold test of 5 deg. F.

Lubricants for Outside Use Require a Low Cold Test

A variety of devices is used to determine the cold test of an oil. However, an ordinary test tube is quite satisfactory. The oil should be placed within the tube and cooled slowly and the temperature noted on a thermometer which is placed in the oil. The lowest temperature at which the oil will still flow when the tube is tilted is the pour test of the oil. Careful observation and some experience are required to make this test of value. The cold test is, of course, noted at a little lower temperature when the oil loses its mobility and assumes the aspect of a solid.

The cold test is only important when fluidity is demanded under low-temperature conditions, as in outdoor service, such as railway work, quarrying and mining or any work in which machinery is used under low-temperature conditions. Drives and oil bearings on conveyors, pumps and other equipment which is often placed in unheated and poorly-sheltered locations should receive the same attention in winter time as an automobile, and have the oil changed. An oil intended for indoor use will cause a heavy friction load, particularly at starting time, if used in exposed locations in winter. Refrigerating machinery presents a low-temperature service problem where a high-grade, low cold test oil is an absolute necessity.

The *volatility or evaporation loss* of an oil is sometimes determined. This loss is evidenced in the loss of weight of the oil when the oil is exposed to high temperature for a specified time. In order to make this test, the oil is placed in an open vessel, heated, and maintained at a definite temperature. The difference in weight between the original oil and the remaining quantity of oil is the evaporation, which is reported as a percentage loss.

There are so many variables present in testing for volatility that the test is not likely to be very accurate. The nature of the container, the method of heating the oil, and the atmospheric or barometric pressure at the time of making the test, all enter into the final results. The volatility test is quite unimportant in lubricating oils, as any good grade of oil over 300 deg. F. flash point will have a volatility loss that is practically negligible.

The *specific heat* of an oil is a measure of the quantity of heat required to raise the temperature of 1 lb. of oil 1 deg. F., as compared with the quantity of heat required to raise the temperature of 1 lb. of water 1 deg. F. The specific heat of a lubricating oil is not of serious importance as regards lubrication itself. When lubricating oils are used for heating baths, fluid mediums and other similar purposes, specific heat may then become a factor as a heat transfer medium.

However, it is interesting to note that the specific heat of oil is about one-half that of water, but varies

with the viscosity, temperature and gravity, and with the different types of oils.

The *body or viscosity* of an oil is probably the test which the purchaser is most interested in and the one upon which he will very likely select an oil for a specific job. This test is conducted by means of a viscosimeter. In this country, the instrument used is the Saybolt viscosimeter, while Great Britain uses the Redwood, and continental Europe the Engler. The Saybolt readings are tabulated in seconds of time, and the Redwood and Engler in degrees.

Briefly, viscosity is the time in seconds required by a given quantity of oil to flow through a standardized orifice at a definite temperature. This is the Saybolt method of measurement and is probably the most widely used. Viscosity readings are ordinarily taken at various temperatures between 100 deg. F. and 210 or 212 deg. F.

It must not be supposed that because two oils have the same readings at say, 100 deg. F., they will also have the same viscosity at 160 or 180 deg. F. Some oils, due to their origin and blending, retain their body better than other oils which are apparently the same. Such oils may have a lower viscosity at the lower temperature and a higher viscosity at the highest temperature; that is, a more constant body is retained by the oil over a wide range of temperatures. This characteristic is very desirable in a lubricating oil, especially for conditions where there are fluctuations of temperature. At the lower temperature, the internal friction of such an oil is relatively low, whereas at the higher temperature the same oil will maintain its body and lubricating capacity. Wide range of viscosity due to temperature fluctuations is generally an undesirable feature of a lubricating oil and one that should be avoided as far as possible. This is not so essential when selecting an oil for a definite operating temperature.

How Viscosity Affects the Use of the Lubricant

Lubricating oils vary in viscosity from 60 sec. Saybolt to over 3,000 sec. at 100 deg. F., beyond which the oils assume the consistency of semi-solids. The lighter oils are used for light, high-speed work where small clearances are the rule. As they increase in body, they find their usefulness in the slower and heavier work where the clearances are larger and where a thicker film of oil is necessary.

Viscosity of an oil is sometimes an indication of its fitness for a particular job. For example, a bearing with no mechanical imperfections, may run quite warm when an oil of a certain body or viscosity is introduced. When an oil of a little lower viscosity is introduced, the temperature of the bearing will drop many degrees. This drop in temperature is due to the lower friction loss in the oil itself. The lighter oil having less internal friction naturally absorbs less power as the shaft rotates and consequently produces less heat. Such power losses quickly run into money losses in terms of unnecessary power or fuel. High bearing temperatures may be due to the use of oil of a viscosity unsuited to the work and are not necessarily indications of imperfect mechanical conditions or abnormal pressures.

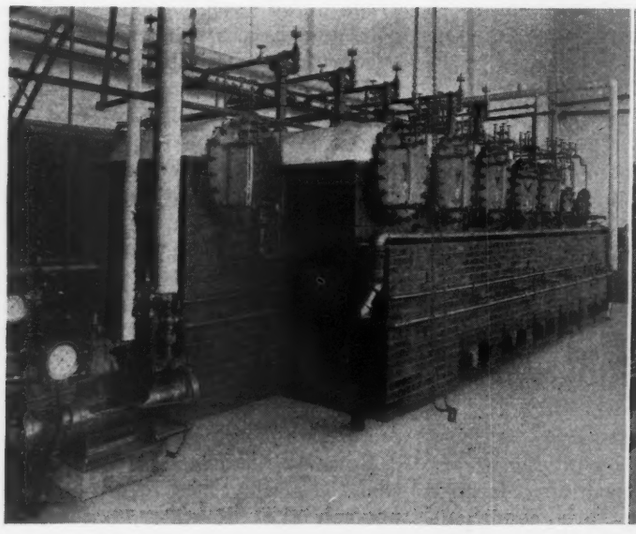
For steam cylinder lubrication, the viscosity of the oil is an important factor. Steam pressure and temperature, the speed of the engine, the load and consequently the volume of steam passing into the cylinder, are factors in determining the body of the oil to be used in the cylinder. In the first place the oil must be easily atomized; it must be broken up by the steam and distributed to all internal parts requiring lubrication. It must not have too heavy a body to do this. Next, it must seal and lubricate the valves, piston, and cylinder walls so that the full power of the steam may be utilized in pushing the piston forward. These two factors must be considered carefully in selecting the steam cylinder lubricant. Viscosity enters into the selection to the extent that the oil will neither be too heavy to be distributed by the steam nor too light to seal the piston and lubricate the parts.

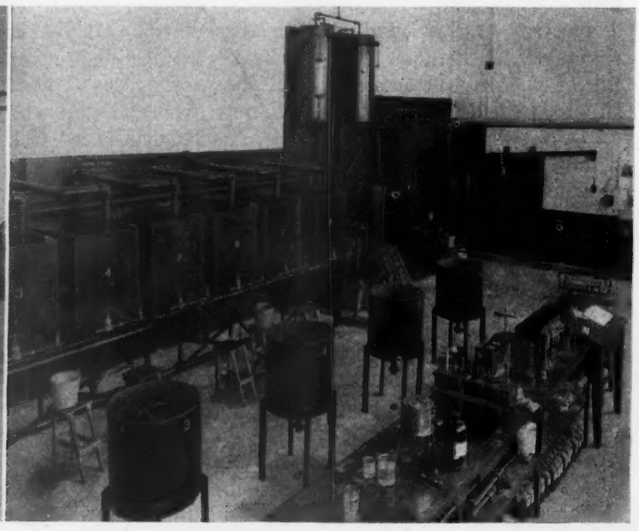
Lubricating oils made from Western crudes are high in viscosity at low temperatures as compared with oils made from the Eastern crudes, but they decrease in viscosity much faster as the temperature is increased. The first mentioned are asphaltic base oils, whereas the Eastern crudes are paraffin base oils.

Selecting a lubricant for a particular service is a task which calls for a thorough knowledge of lubrica-

Economical manufacture of standard quality products is studied in experimental refineries such as are shown here.

These illustrations show two experimental distilling units where actual refining processes are carried on in miniature and the product produced under properly controlled laboratory methods.





tion and of the source and manufacture of the oil. Since viscosity is the most common characteristic used in selecting an oil for any particular purpose it is well to keep in mind that the oil which should be used depends upon the temperature of the bearing, the pressure on the bearing, the speed, the type of bearing, and the method of application. The following generalizations may be made:

(1) High pressure requires high viscosity oil. (2) High temperature requires high viscosity oil. (3) High speed requires low viscosity oil. It is obvious that many installations necessitate a compromise on these factors, particularly when it is remembered that additional complications arise due to the type of bearing and method of application. In general it is well to select an oil which is of medium viscosity, as between the heavy and light viscosities which would be indicated as desirable by the three generalizations mentioned.

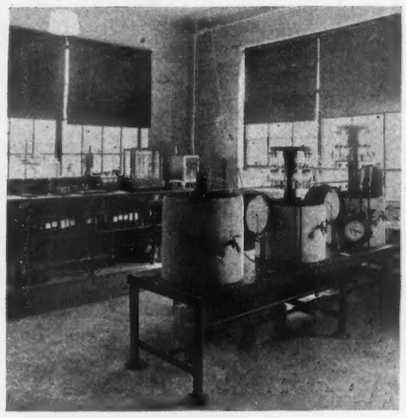
While viscosity is one of the more important "tests" or specifications of lubricating oils, it should be remembered that, after all, it is merely *an indication* of the fitness of an oil for a job. It is in no sense a guarantee that the right oil has been selected.

Oils that are subject to long, continuous use, as in circulation systems of steam turbines, or steam engines, or in the crankcases of internal combustion engines where there is likely to be contamination with water or other impurities, must have a special quality that resists the formation of an emulsion. This means that compounding of mineral oils with animal or vegetable oils is prohibited, as these oils emulsify readily when mixed with water. Mineral oils, on the other hand, do not mix easily with water but even with what is known as "straight mineral" oil, there is a difference in the resistance to water contamination, technically known as "demulsibility."

Only high-grade oils, especially treated and manufactured will resist the tendency to emulsify. With proper care they will retain their original characteristics over long periods.

The *demulsibility test* is a measure of the tendency of the oil to separate from water and is useful only in determining the separating qualities of oils manufactured especially to resist emulsification in service. It is only one of many testing methods in use by the oil refiner in producing oils for lubricating purposes.

There are other tests which are more a problem for the oil chemist than for the purchaser or user of oils. For instance, the *acidity test* is used to determine what, if any, acids may be present as a result of adulteration or improper refining. An oil which has not been well neutralized will sometimes change its characteristics during use or storage. Freedom from acidity is important in Diesel engine lubrication.



Problems in connection with transformer oils are studied in this part of the laboratory.

While transformer oil requirements differ somewhat from those required for lubricating oils, some of the testing procedure and the specifications are based on similar tests for both. One of the tests of particular importance for a transformer oil is the sludge test, which indicates how long an oil will stand up without the formation of a sludge which would decrease its insulating value. Also, a transformer oil must be well neutralized.

The *sludge* test, which determines the tendency to form a sludge, has comparatively little bearing on lubrication, but is of interest to the manufacturer and important in determining the insulating life and value of transformer oils. The *breakdown test*, which indicates the temperature at which the oil begins to "crack" and "break down" into lighter and more volatile oils, is of little value in that practically none of the lubricants will break down under 650 deg. F., which is far above the temperatures encountered in ordinary usage. This test is, however, sometimes made on turbine oils.

Such tests require the services of an expert chemist. They cannot be properly classified under the term "specification," although they have to do with the nature and make-up of the oil.

Greases are not tested in the same way that oils are, owing to the great differences in their nature and characteristics. Instead of speaking of "viscosity" when referring to grease, the term *"consistency"* is used. The only quality tests that can be conducted on greases are those for determining the presence of free acid or alkali. Such tests do not establish the lubricating value of a grease nor do they indicate the uniformity of the product. It can only be said that uniformity is not so readily determined in grease products as it is in lubricating oil products.

It is evident from the foregoing paragraphs that the chemical and physical tests which are applied to lubricants, especially to oils, in no way evaluate the oils as lubricants. Lubrication in the true sense of the word demands more than the application of an oil to a bearing or other machine part that may require oil so that the machine will run without wear or renewing of parts; that is only one phase of the industrial problem.

True lubrication is the application of the oil: (*a*) for the maintenance of a complete and perfect film; (*b*) for the maintenance of the perfect film with the minimum of friction and power consumption; (*c*) economical application.

The solution of the lubrication service problem does not lie in securing oils answering to a certain set of specifications. It does not consist of a comparison of several sets of specifications and selection of the oil for the job by theoretical analysis.

Bearing lubrication is a practical problem and one that is solved best by the study and observation of the practical use of lubricants under conditions of actual service. This involves the practical demonstration of the suitability of the oil for the work, its ability to meet the conditions of service, and its capacity for continued performance over a period of time. The correct oil for a purpose is the result of the study of lubrication problems and the development of a lubricant to satisfactorily meet the conditions when used properly.

In order to produce oils uniformly, the manufacturer must gage his product against certain standards or specifications which are determined by tests, so that when the customer buys a brand of oil, whether it be

(Please turn to page 133)

Fig. 1—Belt drives are used almost exclusively in this plant.
Individual drive is used throughout and belt drive is an economical method of reducing the high motor speed to the low speed required at the presses. Note the use of pedestals for mounting the motors and the convenient location of the motor starting switches with reference to the machine operators.

Power Service Layout for Small Motor Drives

including features of the electrical distribution system, the manner of mounting the motors, and the types of control and drive connections used

By FRANCIS A. WESTBROOK
Consulting Engineer, New Canaan, Conn.

ALTHOUGH laying out a power service installation for a large group of machines requiring only small amounts of power may not seem as difficult as the power layout for the usual mill or factory, still there are many questions to be considered, upon the solution of which rest both the size of initial investment required and the economy of operation after installation.

The Brooklyn plant of Library Bureau furnishes an interesting example. In this installation careful consideration was given to these factors by MacNutt, Watts, and Tankard, electrical engineers and contractors of New York, N. Y., who designed and erected the installation of motors and power drive equipment described in this article.

Library Bureau is a manufacturer of card catalog and filing systems, and various office equipment. The Brooklyn plant of this company specializes on printing and paper products; hence this plant is much in the nature of a printing establishment although it does not have the large presses found in many job printing and newspaper plants.

As might be expected, the power requirements of the individual machines are very small—in only three instances do they exceed ¾ hp. per machine, as may be seen from the accompanying table showing the sizes of motors for the various applications. Also, most of the machines occupy considerable space, compared to the size of the motor used. These factors had a decided bearing on the type of drive that should be used. Group drive was out of the question because the friction losses would be as large as the load itself. Also, many of the machines require from 12 to 15 different speeds; hence individual drive was used throughout and in most cases the motors were connected to the machines by belts except where extremely low speeds were required, when back-geared motors were belted to the machines. The problem then was to supply a large number of small power services.

The building which houses the plant is a new concrete structure

and is provided with conduit built in during construction. Outlets are provided on each floor at practically every post and pilaster on the floor. This feature greatly simplified the conduit layout as it was necessary to provide only the conduit running from these outlets to the individual motors.

Three-phase, 220-volt power was brought into the basement as shown in Fig. 2. A cabinet encloses the switches controlling the power and light supply as well as their respective meters. The supply then passes through the large distribution cabinet shown at the left of the illustration. Two sets of buses will be noticed; the set on the left is for the three-phase power supply, while the set on the right distributes the lighting supply. Individual feeders starting from fuses connected to the buses go to each floor through vertical conduit runs from this panel.

On each floor is a polarized panel box similar to the one illustrated in Fig. 3. A polarized panel box is one in which all wires of one phase are grouped together; in the illustration each door opens into a compartment housing the fuses and bus for one phase. The panel box, shown in the illustration, is centrally located on the fifth floor and has 40 circuits. This type of box saves space, especially where induction motors, requiring three wires, are used. From these distribution panels, conduits radiate to outlets on the posts and pilasters on the floor. These outlets are placed approximately 6 in. above the floor level. From these outlets conduits are run on top of the floor to the individual machines, as shown in Fig. 1. In most instances the conduit could be laid on the floor so as to be parallel to an aisle of machines, as shown in Fig. 1. Placed in this way the conduit does not obstruct traffic in the aisles and the conduit on the floor between machines causes no more trouble than the motors and other equipment around the machines.

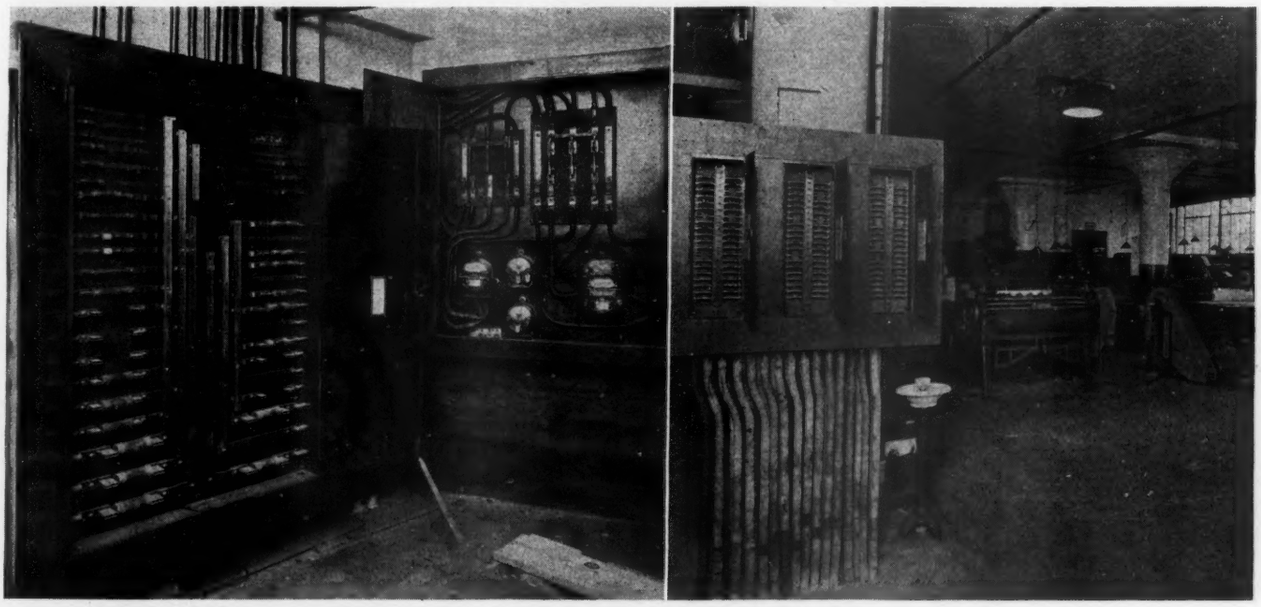
Motors, Control, and Drive Connections Used in a Printing Plant

Name of Machine	Hp. of Motor	R.P.M.	Type of Motor	Control	Drive
10-in. Saw table	3	1,800	Squirrel cage	Man. start. switch	Belt
7x¼-in. Grinder	½	1,800	Squirrel cage	Man. start. switch	Direct
Small drill	½	1,800	Squirrel cage	Man. start. switch	Belt
Dewey ruling machine	½	1,200	Wound rotor	Start sw. & sec. res.	Belt
Hickok ruling machines	½	1,200	Wound rotor	Start. sw. & sec. res.	Belt
No. 1C Chandler & Farquhar punch	½	900	Squirrel cage	Man. start. switch	Belt
Dewey punches	½	1,200	Squirrel cage	Man. start. switch	Belt
Tabbing machines	½	900	Squirrel cage	Man. start. switch	Belt
E-1 Harris presses	1	1,200	Wound rotor	Start. sw. & sec. res.	Belt
J. T. Robinson rotary board cutters	1½	1,200	Squirrel cage	Man. start. switch	Belt
J. T. Wright paper drill	¼	1,800	Squirrel cage	Man. start. switch	Belt
26-in. Rotary board cutter	½	1,200	Squirrel cage	Man. start. switch	Belt
14-in. Auto feed rotary board cutter	1	1,800	Squirrel cage	Man. start. switch	Belt
Small punch	¼	1,200	Squirrel cage	Man. start. switch	Belt
Intertype machines	½	1,200	Squirrel cage	Man. start. switch	Belt
F. Wesel Prof. press	½	1,200	Squirrel cage	Man. start. switch	Belt
Multi-color auto feed press	¼	1,800	Squirrel cage	Man. start. switch	Belt
15x21 Golding job presses	¾	1,800	Squirrel cage	Man. start. switch	Belt
8x12 Golding job presses	¼	1,800	Wound rotor	Start. sw. & sec. res.	Belt
12x18 Golding job presses	½	1,800	Wound rotor	Start. sw. & sec. res.	Belt
12x18 Miller feeder press equipment	¾	1,800	Wound rotor	Start. sw. & sec. res.	Belt
10x15 Miller feeder press equipment	½	1,800	Wound rotor	Start. sw. & sec. res.	Belt
8x12 Golding job presses	¼	1,800	Wound rotor	Start. sw. & sec. res.	Belt
7x11 Golding job presses	¼	1,800	Wound rotor	Start. sw. & sec. res.	Belt
10x15 Thomson press	½	1,200	Wound rotor	Start. sw. & sec. res.	Belt
Miller saw trimmer	½	1,800	Squirrel cage	Start. sw. & sec. res.	Belt
Metal edge box machine	1	1,200	Squirrel cage	Start. sw. & sec. res.	Belt
Sheridan cutter	2	1,200	Squirrel cage	Man. start. switch	Belt
Miehle vertical presses	1½	1,200	Squirrel cage	Man. start. switch	Belt
Hoole numbering machines	⅓	1,200	Squirrel cage	Man. start. switch	Belt

Man start switch refers to a manually operated motor starting switch, which throws the motor across the line without fuses and afterwards cuts in the fuse protection.

Sec. res. given in the control column, refers to the rheostat in the rotor circuit of wound rotor motors and is used for speed control.

There are a total of 57 motors in this installation. Only the types of applications are listed, the number of motors under each application not being included.



Figs. 2 and 3—Distribution cabinets form the backbone of the power wiring on this job.

The service entrance is shown in the switch and meter cabinet in the illustration at the left. The left-hand switch is for the lighting service while the switch at the right controls the power service. Leads from the power switch run to the left-hand set of busbars in the distribution cabinet, from which run feeders to the various floors of the building. Polarized distribution cabinets, as shown in the right-hand illustration, distribute the individual circuits on a given floor.

Where conduit crosses an aisle, a shallow trench was cut in the floor, the conduit placed therein and covered with cement.

After going across the aisle, the conduit was carried on top of the floor. Three-way or "T" conduit fittings were used for junctions to motors and control.

Rigid conduit was used throughout except for the short stretch of flexible conduit connecting the conduit fitting on the motor to the rigid conduit. This may be seen in Fig. 1. One of the presses in the immediate foreground has been temporarily moved away—its motor can be seen standing second from the right in the foreground.

The arrangement used for enclosing the motor leads can be seen on this motor. These motors were not equipped with fittings to enclose the motor leads and receive the conduit; so an ordinary knockout box, having a hole large enough to go over the outlet for the stator leads, was bolted to the stator frame by means of four machine screws. One of the punchings was knocked out of the side of the box towards the rotor leads (in the case of a wound-rotor motor, as shown in the illustration) and a piece of flexible conduit connected thereto and to the end bell through which the rotor or slip-ring leads passed. A punching was knocked out of the top of the box and flexible conduit was run from this point to the rigid conduit. All splices were made in the knockout box.

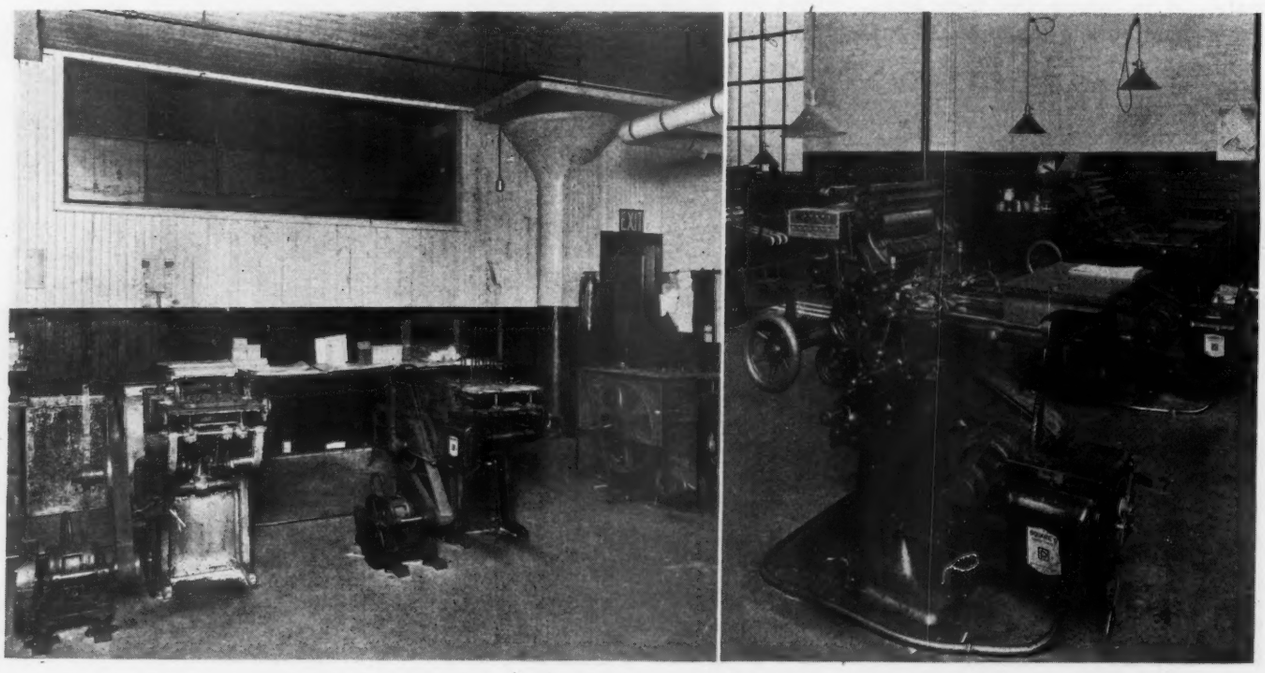
Most of the motors were mounted on the concrete floor, as shown in Figs. 1 and 4. A few, however, were mounted on the frames of the machines themselves, as shown in Fig. 5. The linotype machines have special bases provided on the frames, as also do some of the smaller presses which have a friction drive through a belt working over an idler, and pressing against part of the periphery of a flywheel, as may be seen in the center of Fig. 1.

Some of the motors for the presses were mounted on pedestals as can be seen in Fig. 1. These pedestals are very simple, consisting of two 6-in. pipe flanges, a short length of 6-in. pipe and two pieces of strap iron. The pipe was threaded and one flange screwed tightly to each end. One flange was then bolted to the concrete floor and the two pieces of strap iron bolted to the other flange to form a base on which the motor slide rails were mounted.

From the accompanying table it will be seen that three standard motor speeds were required: namely, 900, 1,200 and 1,800 r.p.m. With the exception of the presses and ruling machines, these motors are of the constant-speed, squirrel-cage type and are belted to their respective drives. The presses require adjustable speed, in some cases as many as 12 or 15 different operating speeds, depending upon the character of the work being done. Wound-rotor induction motors were provided for this service.

The class of labor that operates these machines is of a high order of intelligence; so it was unnecessary to reduce the control methods used to a matter of push-button switches. Manually-operated, across-the-line starting switches are provided for all motors, as may be seen in Figs. 1, 4 and 5. In addition, the variable-speed motors are provided with a manually-operated rheostat which increases or decreases the resistance in the rotor or secondary circuit to obtain the desired motor speed.

Inasmuch as all of the drives are through belts, with the addition of a few back-geared motors, it was necessary to provide guards. In all cases these were made of coarse wire netting formed over strap-iron frames. Good examples of these guards are seen at the left of Fig. 1 and at the right of Fig. 4. In the case of the Harris presses (shown in Fig. 5) it was possible to mount the motor, starting switch, and speed control rheostat all on one frame, which was fastened to the base of the press. It was then a simple matter to run a wire netting guard around the short stretch of belt.



Figs. 4 and 5—Drive arrangements for automatic cross cutters and high-speed card presses.

At the left is shown the use of back-geared motors belted to cross cutters used for cutting cards. The motors are mounted directly on the floor and in under the machines to save floor space. The same idea is carried out in the right-hand illustration, showing the complete power drive equipment for the high-speed card presses mounted on an angle-iron frame which is bolted to the machine base. The rheostat for varying the motor speed may be seen mounted on this frame directly behind the motor starting switch. It is operated from the front.

Here are some practical ways for

Recording Rewinding Data for Cross Connections

together with the details of typical jobs on which accurate information is essential when laying out and checking up a new winding

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THE CROSS or equalizer connections provide a factor of safety against circulating currents between brushes of like polarity, due to changes in the magnetic field of a direct-current machine caused by bearing wear or other conditions that make the armature operate in unequal magnetic densities under the different field poles. Equalizer connections are mostly used on large machines with lap windings or with wave windings having more than two circuits. In some rotary converters the collector rings and their taps to the winding are used as cross or equalizer connections also. In other cases the spacing of the alternating-current taps is different from the cross connector spacing. These details are discussed in the examples presented in this article.

IN THE article that appeared in the January, 1926, issue of INDUSTRIAL ENGINEER, some practical rules governing the use of cross or equalizer connections were given. In this article examples of the application of the connections are presented, together with methods of recording rewinding data for special machines, as an aid to the winder when checking rewound machines with the original winding and also when laying out a new winding.

In Fig. 1 the winding data are given for a 300-kw., ten-pole, three-phase, 60-cycle, 720-r.p.m. rotary converter, having 120 slots, 360 bars and three coils per cell. This winding also has three a.c. collector rings with five taps per ring, as will be explained under rotary converters. The data in Fig. 1 apply to a winding that has the cross connections behind the commutator in the form of a two-layer winding as shown in Fig. 1 of the January, 1926, issue and the small sketch at *A* in Fig. 1 of this article.

The procedure for taking and checking the data, for cross connections is outlined in what follows: Disregard the taps to the collector rings or consider this as a lap winding with cross connections only. By inspecting the commutator necks or risers, the cross connection taps can be located, and the spacing noted. Then select any one bar that has an equalizer connection attached to it and trace out the coil that connects to the bar. If the machine is less than 100 per cent equalized then check the strap (that is middle, etc., single coil) that connects to the equalizer bar. Trace out the complete coil and mark the top and bottom slots and then draw a sketch like Fig. 1 showing the armature coil. Next, with a test light find the other end of the cross connector, which will be the number of bars divided by pairs of poles on either side of the bar selected. Then line out from the bar to which the other end of one cross connection is at-

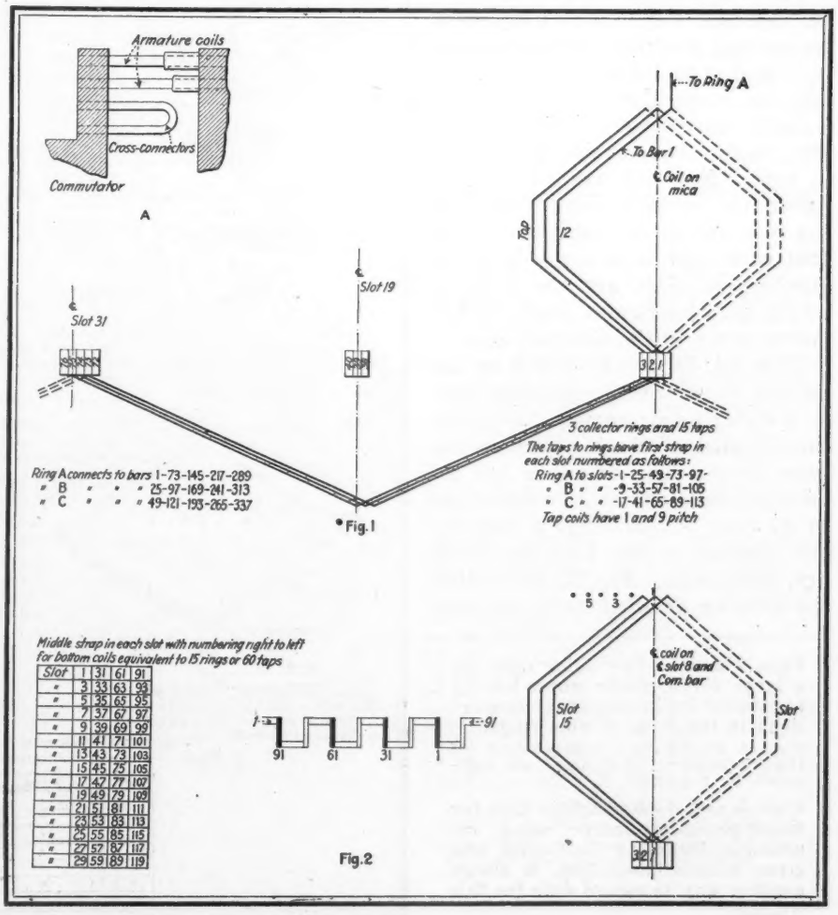

Armature coils
Cross-connectors
Commutator
A
To Ring A
To Bar 1
Coil on mica
Tap
12
Slot 19
Slot 31
3 collector rings and 15 taps
The taps to rings have first strap in each slot numbered as follows:
Ring A to slots-1-25-49-73-97-
" B " " -9-33-57-81-105
" C " " -17-41-65-89-113
Tap coils have 1 and 9 pitch
Ring A connects to bars 1-73-145-217-289
" B " " " 25-97-169-241-313
" C " " " 49-121-193-265-337
Fig. 1
Middle strap in each slot with numbering right to left for bottom coils equivalent to 15 rings or 60 taps
Slot 1 31 61 91
" 3 33 63 93
" 5 35 65 95
" 7 37 67 97
" 9 39 69 99
" 11 41 71 101
" 13 43 73 103
" 15 45 75 105
" 17 47 77 107
" 19 49 79 109
" 21 51 81 111
" 23 53 83 113
" 25 55 85 115
" 27 57 87 117
" 29 59 89 119
91
61
31
1
Coil on slot 8 and Com. bar
Slot 15
Slot 1
Fig. 2

Fig. 1—This is the winding diagram of a 300-kw., ten-pole, three-phase, 60-cycle, 720-r.p.m. rotary converter having 120 slots and 360 bars with 360 cross connectors.

Fig. 2—Diagram for recording rewinding data for 1,000-kw., eight-pole generator with lap winding in 120 slots, 360 bars, three coils per cell. Every other slot is cross-connected.

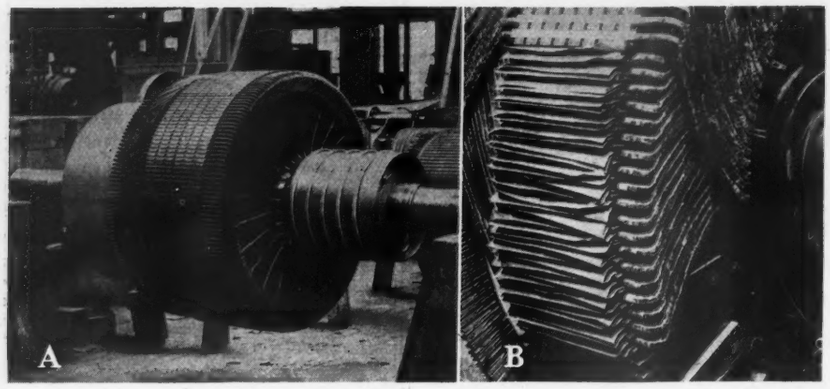


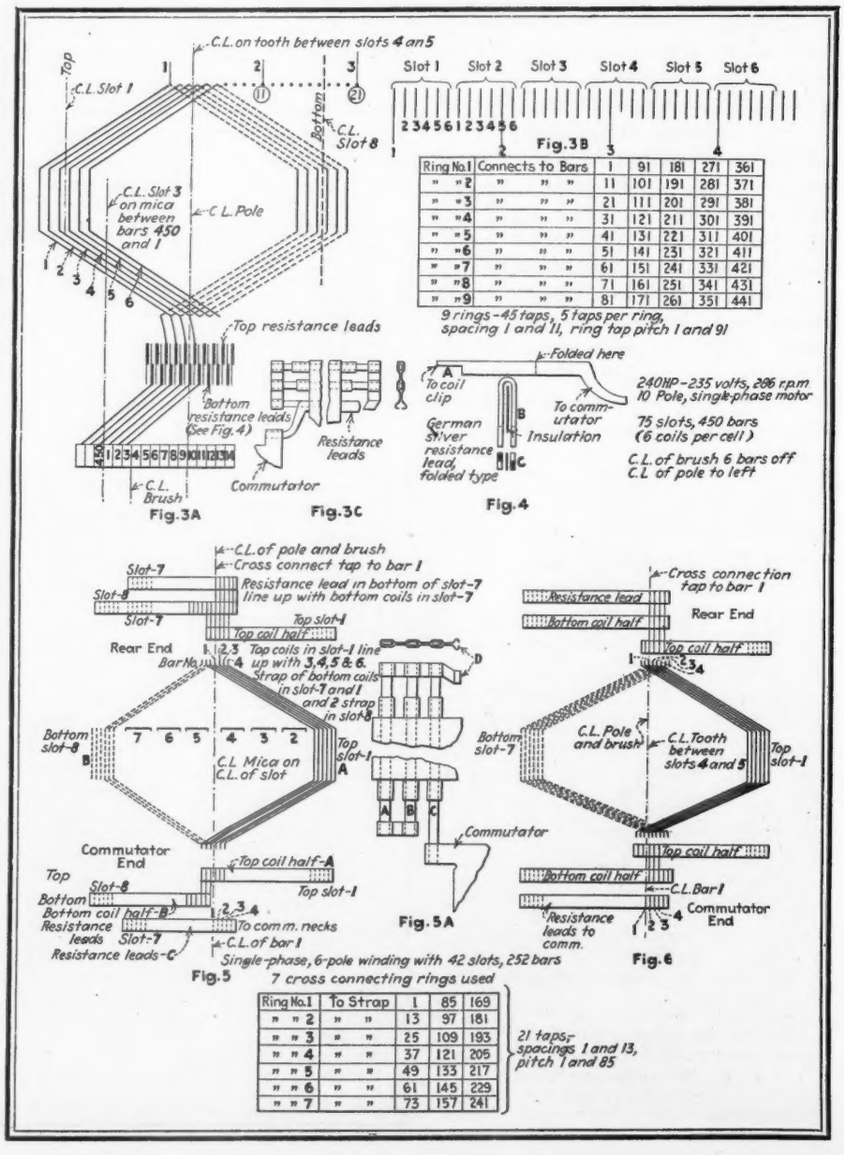
Fig. 7—In A is shown a rotary converter armature, with four collector rings, for a 250-hp., two-phase, 12-pole machine. In B, showing the rear end of the armature, the a.c. taps from the bottom of the tap coils and also the spacing of these coils can be seen.

tached, to the slot on a line with this bar and mark it off on the sketch as shown. Also locate the center line of the cross connector on a bar and slot, etc.

If the keyway in the shaft is in view, it is better to find the slot or tooth that is on the center line of the keyway. Then use this in locating a data coil. This will be shown later.

In Fig. 2 is shown the method of recording the rewinding data for a 1,000-kw. generator, eight poles, lap winding, 120 slots, 360 bars, three coils per cell, coil pitch 1-and-15. The cross connections, at the rear of the armature are as shown in Figs. 6 and 7 of the January, 1926, issue. In this case slot numbers are used in locating the cross connections as indicated in the table of Fig. 2. The spacing in bars or single coils, is 1-and-7, the connector pitch being 120÷4=30 in slots and 360÷4=90 in bars. Note the method of indicating the cross connector data at the rear end of the armature. The dots each represent a slot and the numbers of slots are the ones to which a connection is made to the middle strap in the slot indicated.

Figs. 3*A*, 3*B* and 3*C* illustrate the method of recording rewinding data on a difficult job: namely, the armature of a large, single-phase, series-type motor. The armature has resistance leads and cross connections in the form of nine rings at the rear end, similar to Fig. 5 of the January, 1926, issue. Fig. 3*C* shows that the winding uses half-coils, the rear ends being joined together with clips. A special clip is used for the cross connectors, as shown in Fig. 3*C*. The sketch also shows that the coils are connected to the commutator through resistance leads placed in the bottom of each slot. These resistance leads are made of german silver or other resistance alloy. Those shown in Fig. 3*C* are made from flat ribbon bent over flat and a piece of insulation placed between the folds. Fig. 4 shows the method of folding. View *A* shows the flat strip with the top and bottom leads punched out. It is next folded along the dotted line, as in *B*, which shows the top view of the folded piece and the insulation between the folds. *C* is the front view. Six of these are tapped together to form a winding unit. Fig. 3*C* shows the coils are joined together on the front (commutator) end with clips in such a manner as to give the same results as though the coil ends were placed in the commutator necks; that is, a


C.L. on tooth between slots 4 an 5
Top
C.L. Slot 1
Bottom
C.L. Slot 8
C.L. Slot 3 on mica between bars 450 and 1
C.L. Pole
Top resistance leads
Bottom resistance leads (See Fig. 4)
Resistance leads
Commutator
C.L. Brush
Fig. 3A
Fig. 3C
Slot 1 Slot 2 Slot 3 Slot 4 Slot 5 Slot 6
Fig. 3B
Ring No. 1 Connects to Bars 1 91 181 271 361
" " 2 " " " 11 101 191 281 371
" " 3 " " " 21 111 201 291 381
" " 4 " " " 31 121 211 301 391
" " 5 " " " 41 131 221 311 401
" " 6 " " " 51 141 231 321 411
" " 7 " " " 61 151 241 331 421
" " 8 " " " 71 161 251 341 431
" " 9 " " " 81 171 261 351 441
9 rings-45 taps, 5 taps per ring, spacing 1 and 11, ring tap pitch 1 and 91
Folded here
To coil clip
To commutator
German silver resistance lead, folded type
Insulation
Fig. 4
240 HP-235 volts, 286 r.p.m. 10 Pole, single-phase motor
75 slots, 450 bars (6 coils per cell)
C.L. of brush 6 bars off C.L. of pole to left
C.L. of pole and brush
Cross connect tap to bar 1
Slot-7
Slot-8
Slot-9
Resistance lead in bottom of slot-7 line up with bottom coils in slot-7
Top slot-1
Top coil half
Rear End
Bar No.
Top coils in slot-1 line up with 3,4,5 & 6.
Strap of bottom coils in slot-7 and 1 and 2 strap in slot-8
Bottom slot-8
C.L. Mica on C.L. of slot
Top slot-1
Commutator End
Top
Bottom
Top coil half-A
Bottom coil half-B
Resistance leads
Slot-7
Resistance leads-C
To comm. necks
C.L. of bar 1
Fig. 5
Fig. 5A
Cross connection tap to bar 1
Resistance lead
Bottom coil half
Rear End
Top coil half
Bottom slot-7
C.L. Pole and brush
C.L. Tooth between slots 4 and 5
Top slot-1
Commutator
Top coil half
Bottom coil half
C.L. Bar 1
Commutator End
Resistance leads to comm.
Fig. 6
Single-phase, 6-pole winding with 42 slots, 252 bars
7 cross connecting rings used
Ring No. 1 To Strap 1 85 169
" " 2 " " 13 97 181
" " 3 " " 25 109 193
" " 4 " " 37 121 205
" " 5 " " 49 133 217
" " 6 " " 61 145 229
" " 7 " " 73 157 241
21 taps, spacings 1 and 13, pitch 1 and 85

Figs. 3 and 4—Rewinding data for a large single-phase motor having resistance leads and cross connections in the form of nine rings. Fig. 4 shows the construction of the resistance leads used as indicated in Fig. 3*C*.

Figs. 5 and 6—Rewinding data for single-phase armature using resistance leads as half-coils and cross connections. Fig. 6 shows another way to record data for this winding.

continuous circuit. Thus the armature circuit is closed through the clips and only the resistance leads that are connected to the bars in contact with a brush are in circuit at any one time.

In taking data on a winding of this type it is best to work downward; that is, start with any one top coil. Mark the slot No. 1, and contrary to previous instructions, make the slot numbers run clockwise. Then find the center line of this top group of coils and make a sketch showing the steps made. At the same time note the equalizer connections and make necessary notations. Then mark the slots and clips and remove enough top coils to expose the bottom coils to view. Next, from the marked clips and slot, trace out the corresponding bottom conductors and fill in the sketch; also mark the slots. Next hold a test light on the front clip that the top strap (No. 1) is connected to and with the other test lead explore the commutator until a light is found on *one* bar only. This will locate bar No. 1. The next step is to locate the slot that contains the resistance leads in contact with top coils *1, 2, 3, 4, 5, 6.* First mark the clips *1, 2, 3,* etc., to correspond with the top strap marking. Then lift enough bottom coils, working back towards slot No. 1, to expose the resistance coils. It is then an easy matter to trace out and note the slot that contains the leads. In this case, the resistance leads in slot

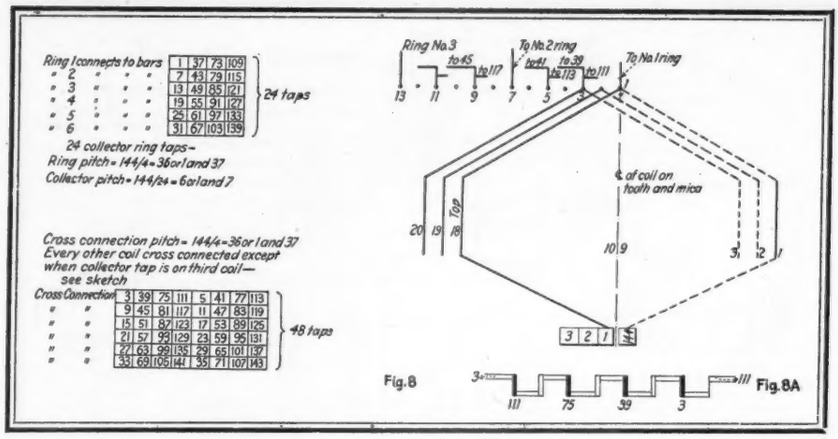

Ring No.3
To No.2 ring
To No.1 ring
24 taps
24 collector ring taps—
Ring pitch = 144/4 = 36 or 1 and 37
Collector pitch = 144/24 = 6 or 1 and 7
Cross connection pitch = 144/4 = 36 or 1 and 37
Every other coil cross connected except when collector tap is on third coil—see sketch
48 taps
Top
Fig. 8
Fig. 8A

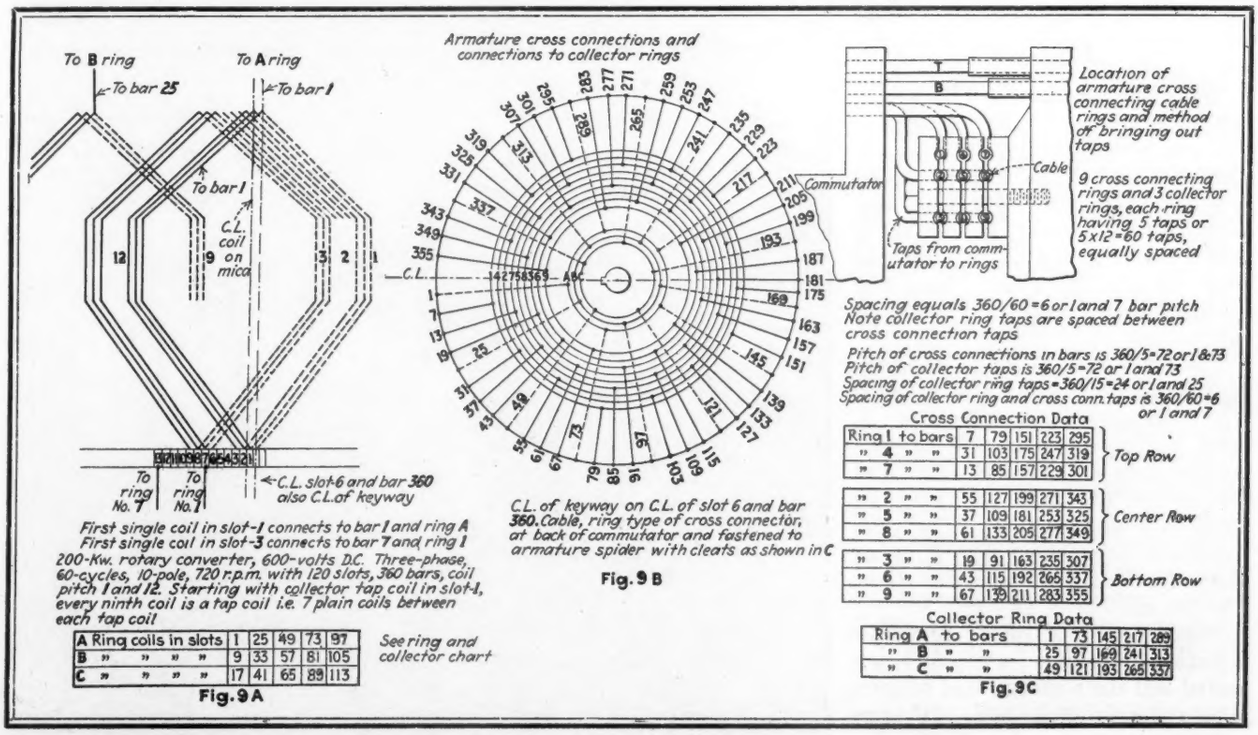
Fig. 8—Diagram and data for eight-pole, six-phase rotary converter with 144 slots and bars. Coil pitch is 1-and-18. Six collector rings with the a.c. taps also used as equalizer connections give 50 per cent equalization.

No. 4 connect to top straps *3, 2, 1* in slot No. 1, and top straps *6, 5, 4* in slot No. 75. These data are then put down as shown in Fig. 3, which also shows that an equalizer tap is made to top strap No. 1, in slot No. 1. By checking further we find the next tap is made to strap No. 5 in slot No. 2, as the spacing is 1-and-11 or ten. Next, on checking the taps to ring No. 1, we find five taps, one each from straps *91, 181, 271, 361, 1.* Considering the top straps as bars, the cross connecting data are then put down as in Fig. 3*C* and the upper part of Fig. 3*A*.

With motors of this type, when the complete machine is available, it is good policy to mark the pole and brush center line on the commutator by scratching the bar with a knife before removing the armature from the frame. Fig. 3*A* shows that the center line of the pole and coil falls on the mica between bars *9* and *10*, that the center line of the brush is between bars *3* and *4*, and that the center line of *slot* No. 3 falls on the mica between bars *450* and *1*.

In Fig. 5 are shown the data for a single-phase armature with resistance leads and cross connections.

Fig. 9—In A a method is shown for recording data for a rotary converter using flexible cable at the rear of the commutator for the equalizer connections. In B the connections to the collector rings are illustrated, and in C the method of attaching the rings to the armature core is shown.


To B ring
To A ring
To bar 25
To bar 1
C.L. coil 9 on mica
C.L. slot-6 and bar 360 also C.L. of keyway
First single coil in slot-1 connects to bar 1 and ring A
First single coil in slot-3 connects to bar 7 and ring 1
200-Kw. rotary converter, 600-volts D.C. Three-phase, 60-cycles, 10-pole, 720 r.p.m. with 120 slots, 360 bars, coil pitch 1 and 12. Starting with collector tap coil in slot-1, every ninth coil is a tap coil i.e. 7 plain coils between each tap coil
A Ring coils in slots 1 25 49 73 97
B " " " " 9 33 57 81 105
C " " " " 17 41 65 89 113
See ring and collector chart
Fig. 9A
Armature cross connections and connections to collector rings
C.L. of keyway on C.L. of slot 6 and bar 360. Cable, ring type of cross connector, at back of commutator and fastened to armature spider with cleats as shown in C
Fig. 9B
Location of armature cross connecting cable rings and method of bringing out taps
Cable
Commutator
9 cross connecting rings and 3 collector rings, each ring having 5 taps or 5x12=60 taps, equally spaced
Taps from commutator to rings
Spacing equals 360/60 = 6 or 1 and 7 bar pitch
Note collector ring taps are spaced between cross connection taps
Pitch of cross connections in bars is 360/5 = 72 or 1 & 73
Pitch of collector taps is 360/5 = 72 or 1 and 73
Spacing of collector ring taps = 360/15 = 24 or 1 and 25
Spacing of collector ring and cross conn. taps is 360/60 = 6 or 1 and 7
Cross Connection Data
Ring 1 to bars 7 79 151 223 295 Top Row
" 4 " " 31 103 175 247 319
" 7 " " 13 85 157 229 301
" 2 " " 55 127 199 271 343 Center Row
" 5 " " 37 109 181 253 325
" 8 " " 61 133 205 277 349
" 3 " " 19 91 163 235 307 Bottom Row
" 6 " " 43 115 192 265 337
" 9 " " 67 139 211 283 355
Collector Ring Data
Ring A to bars 1 73 145 217 289
" B " " 25 97 169 241 313
" C " " 49 121 193 265 337
Fig. 9C

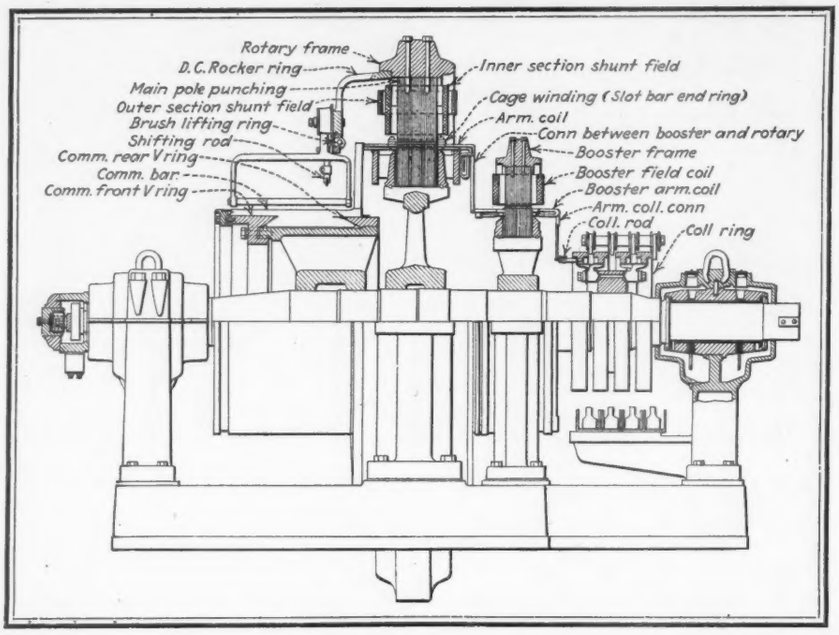


Fig. 10—Cross-section of a synchronous booster converter armature showing connections between the booster and the collector rings.

In this case the resistance leads connect to the coil at the rear end, pass through the armature slot and connect to the commutator at the rear end, as shown in Fig. 5*A*. A special clip is used to make the cross connection at the rear end also. The resistance leads are in the form of half-coils. In taking data, we start at the top and work down to the resistance leads. The result is shown in Fig. 5.

In Fig. 6 is shown another way of recording the bottom coil and resistance coil data for the armature shown in Fig. 5. This shows that the bottom coil in slot 7 lines up on both ends with the resistance leads in slot 7. The cross connection data are given in Fig. 5.

Rewinding data required for windings of rotary converter armatures will now be considered. In Fig. 7*A* a 250-hp., two-phase, 12-pole rotary converter armature with four collector rings is shown. In Fig. 7*B* is shown the rear end of an armature with the a.c. tap coils. Note the spacing and the method of bringing out the taps.

The rules that apply to collector ring connections apply also to ring-type equalizer connections: that is, there will be as many taps to each ring as there are pairs of poles. The spacing of the taps per ring, or pitch, is equal to $B \div P$. The total number of taps is equal to $P \times R$ or pairs of poles times number of rings. The tap spacing is $(B \div P) \times R$.

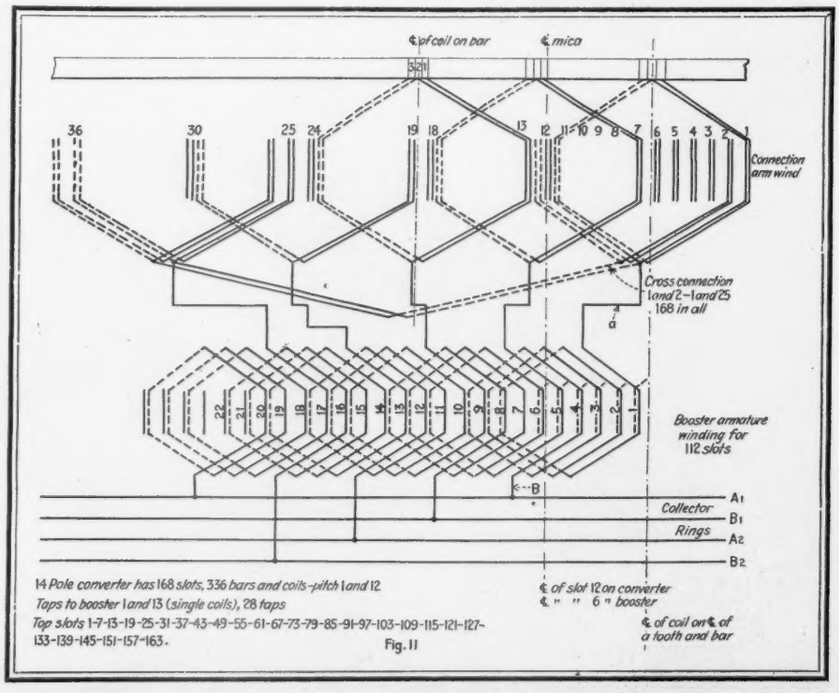
The majority of rotary converter armature windings are cross-connected and the a.c. taps tend to complicate the winding data. In some cases the collector rings and their taps to the winding are used as cross connections also. In other cases the spacing of the a.c. taps is different from the cross-connector spacing; therefore, care must be taken in recording these data.

In Fig. 7*A* the winding has 192 slots and bars, 4 rings, 12 poles, 6 taps to each ring. The ring tap pitch is 192÷6=32, or 1-and-33 bars or slots. The total number of taps equals 6×4 or 24, and tap spacing is 192÷24=8, or 1-and-9 bars or slots.

Fig. 11—Method of recording rewinding data for a rotary converter and booster winding.

In Fig. 1, one method is shown for recording winding data for a rotary armature, with the cross connections at the rear of the commutator. The winding in Fig. 1 is three-phase; therefore, there will be three rings and for ten poles there will be a total of 15 taps (five per ring) spaced as shown in the table with Fig. 1, which gives the data in bars and slots. This is necessary with more than one coil per cell windings, to enable the winder to space the coils. For instance, in winding the armature shown in Fig. 1 he would start with a tap coil; then put in eight plain coils; then a tap coil, and repeat.

Fig. 8 shows the data for an eight-pole, six-phase rotary with 144 slots and bars, coil pitch 1-and-18, and six collector rings. In this case the a.c. taps are also used as equalizer connections, resulting in 50 per cent equalization. That is, with six rings and eight poles, there will be 6×4 or 24 ring taps spaced as shown in the table in Fig. 8. The pitch is 144÷4=36, or 1-and-37 bars; spacing equals 144÷24=6, or 1-and-7. The ring layout is shown at the top of the data diagram. The machine also has a number of S-shaped involute cross connectors tapped into the rear of the winding, as indicated in the cross connection table in Fig. 8, making a total of 48+24=72 taps. Fig. 8*A* shows one series of equal-


℄ of coil on bar
℄ mica
36 30 25 24 19 18 13 12 11 10 9 8 7 6 5 4 3 2 1
Connection arm wind
Cross connection 1 and 2—1 and 25 . 168 in all
Booster armature winding for 112 slots
A1
B1
A2
B2
Collector Rings
14 Pole converter has 168 slots, 336 bars and coils-pitch 1 and 12
Taps to booster 1 and 13 (single coils), 28 taps
Tap slots 1-7-13-19-25-31-37-43-49-55-61-67-73-79-85-91-97-103-109-115-121-127-133-139-145-151-157-163.
℄ of slot 12 on converter
℄ " " 6 " booster
℄ of coil on ℄ of a tooth and bar
Fig. 11

izer taps while Fig. 8 shows that there are two series of cross connection taps between the a.c. ring taps.

In Figs. 9*A*, 9*B* and 9*C* a method of recording data is shown for a machine similar to the one illustrated in Fig. 1; that is, one in which a flexible cable is used at the rear of the commutator for the equalizer connections. Fig. 9*C* shows the method of attaching the rings to the armature core and also the tap spacing. Note that rings *1*, *4*, *7* occupy the top row, rings *2*, *5*, *8* the middle row, and rings *3*, *6*, *9* the bottom layer.

Fig. 9*B* locates the equalizer taps and the a.c. collector ring taps in relation to the center line of the keyway, bar and slot. It also brings out the fact that the a.c. collector ring taps are used as equalizer connections. These taps are represented by dotted lines, making a total of 60 equalizer taps or 60÷360=16.6 per cent equalization; a spacing of 360 ÷60=6, or 1-and-7.

Fig. 9*A* gives the coil and tap data with reference to the keyway. This sketch also gives the tap coil spacing.

From the examples just given of rotary armature windings, a check should be made to determine the relation between the a.c. collector ring taps and the equalizer connections and the information recorded in a manner that will enable any winder to rewind the armature and duplicate the original winding in every respect, including the spacing of taps with relation to keyway, a.c. and equalizer taps.

There is another type of machine that has a somewhat more complicated winding. This is the synchronous booster converter. In this type a synchronous, alternating-current generator or booster is added between the converter armature and the a.c. collector rings. In general the booster has the appearance of the ordinary direct-current generator; that is, there is a stationary field and a revolving armature, with distributed winding but without a commutator. A brief explanation of the function of this booster will help to give an idea what effect wrong data would have on the operation of the machine.

The booster main poles are in line with the converter main poles. This enables the booster winding to give an equal boost or buck with a given field excitation. Then by varying the field excitation of the booster, its armature voltage, which is alternating in character, may be increased or decreased and its voltage can be added to (boost) the d.c. voltage or it can be subtracted from (buck) the d.c. voltage. The voltage variation generally runs between 30 volts below normal to 30 volts above normal line voltage.

In Fig. 10 is shown a cross section of a synchronous booster converter

Taps for Booster and Converter Windings

There are 28 taps (7 to each ring) from booster winding to rings. Pitch 1-and-5, (1-and-17 for same phase).

Taps to ring A-1 in top of slots 4, 20, 36, 52, 68, 84, 100
Taps to ring B-1 in top of slots 8, 24, 40, 56, 72, 88, 104
Taps to ring A-2 in top of slots 12, 28, 44, 60, 76, 92, 108
Taps to ring B-2 in top of slots 16, 32, 48, 64, 80, 96, 112

TAPS FROM CONVERTER TO BOOSTER

Rear of Converter Winding to Front of Booster Winding

RING NO.	CONVERTER TOP SLOT NO.		BOOSTER TOP SLOT NO.	REMARKS
A_1	1	to	1	Looking at machine from collector ring side, the strap is in the left-hand side of the slot connector to the booster; also the cross connector.
B_1	7	to	5	
A_2	13	to	9	
B_2	19	to	13	
A_1	25	to	17	There are 168 cross connectors—spacing is 1-and-3 and pitch in single coils is 1-and-25, as shown at rear of converter.
B_1	31	to	21	
A_2	37	to	25	
B_2	43	to	29	
A_1	49	to	33	On the booster armature slots *3, 7, 11, 15, 19, 23, 27, 31, 35, 39, 43, 47, 51, 55, 59, 63, 67, 71, 75, 79, 83, 87, 91, 99, 103, 107,* and *111,* 28 slots, are only half-full, i.e. contain only a top coil half.
B_1	55	to	37	
A_2	61	to	41	
B_2	67	to	45	
A_1	73	to	49	Front pitch on booster is 1-and-7. Rear pitch on booster is 1-and-8.
B_1	79	to	53	
A_2	85	to	57	
B_2	91	to	61	
A_1	97	to	65	Center line of keyway is on center line of slot *12* on converter, and center line of slot *6* on booster armature.
B_1	103	to	69	
A_2	109	to	73	
B_2	115	to	77	
A_1	121	to	81	
B_1	127	to	85	
A_2	133	to	89	
B_2	139	to	93	
A_1	145	to	97	
B_1	151	to	101	
A_2	157	to	105	
B_2	163	to	109	

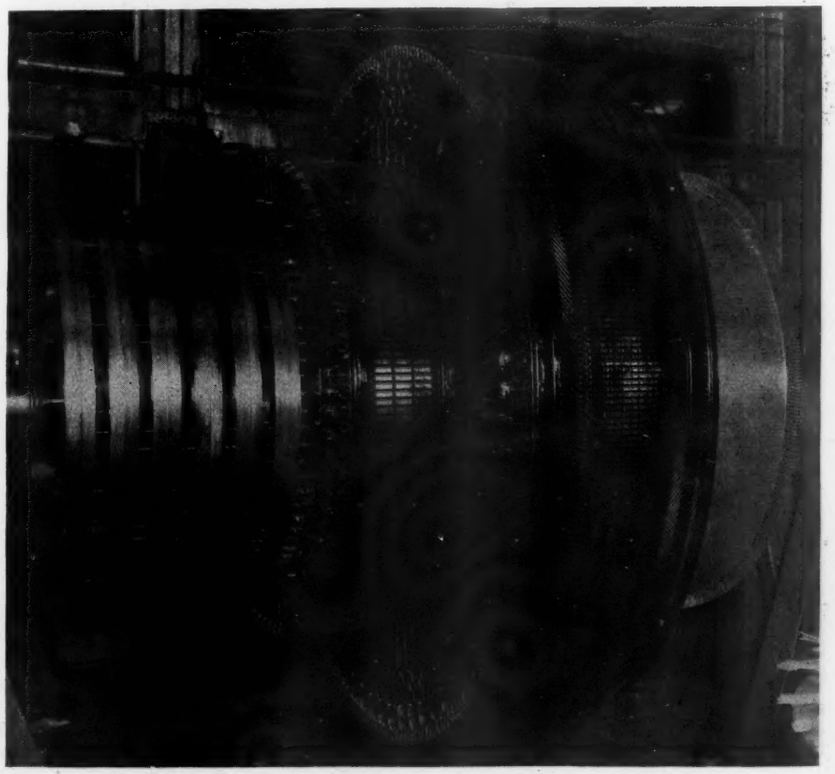


Fig. 12—This shows the complete synchronous booster converter of the type from which data were taken in Fig. 11. Note the taps between the rotary and booster windings.

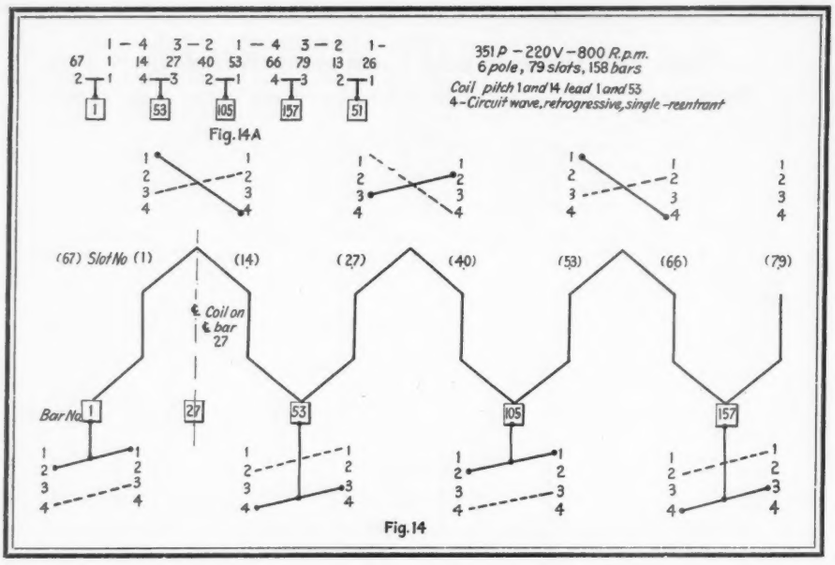


Fig. 14—Here is a simple form for recording data on the winding shown in Fig. 13.
This winding is for a 35-hp., 220-volt, six-pole, 800-r.p.m. motor with 79 slots and 158 bars.

armature, the booster armature, and the connection between the booster and the four collector rings. The taps from the rotary armature to the booster armature can be considered the same, and the same winding rules apply as to a.c. collector ring taps.

Fig. 11 shows a method of recording the rewinding data. Starting with the rotary armature winding which has 168 slots, 336 bars, 14 poles, 28 taps, and 168 cross connections, the equalizer pitch in slots is 168÷7=24, or 1-and-25. The spacing in slots is 1-and-2. In bars the equalizer pitch equals 336÷7=48, or 1-and-49, and the spacing is 336÷168=2, or 1-and-3. The coil pitch is 1-and-12, the tap spacing in slots is 168÷28=6, or 1-and-7, and the ring pitch is 168÷7=24, or 1-and-25.

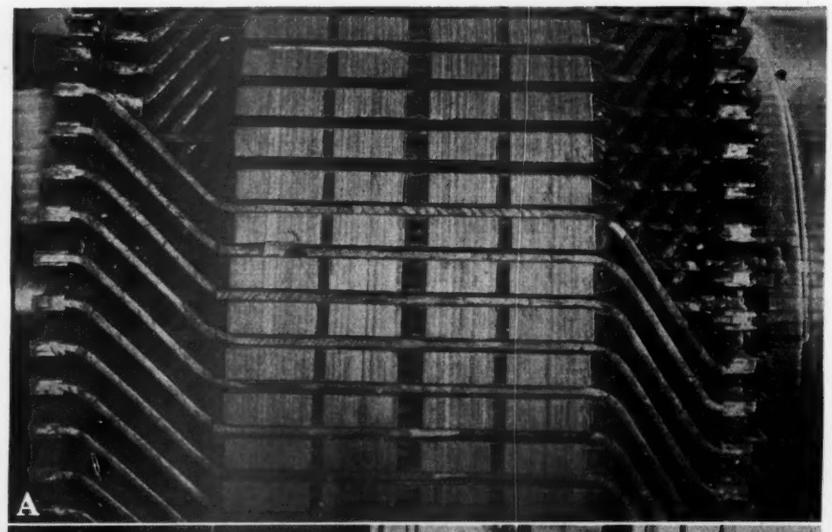
Note the manner of tying the booster winding with the rotary winding by lining out from slot *12* on the rotary to slot *6* on the booster. The center lines of these slots coincide, as will be noted.

By following the tap *a* from the top of rotary armature slot *1* to the top coil in slot *1* of the booster winding, we find the booster circuit is from slot *1* to bottom *8*, to top *2*, bottom *9*, top *3*, bottom *10*, top slot *4* and then out to the A_1 ring on tap *B*. Or, the conductors in the top of slots *1*, *2*, *3*, *4* and in the bottom of slots *8*, *9*, *10* are in series with the tap from the rotary winding and the A_1 ring. This series of coils forms a separate group, there being as many of these groups as there are rings times pairs of poles. Also note that there will be a number of slots that contain only one conductor. This slot will be one booster coil pitch ahead of the slot that contains the ring tap; that is, the booster coil pitch is 7 or 1-and-8 and the tap *B* to ring A_1 is from the top of slot *4*. Then 4+7=11, or slot *11* will not have a bottom conductor.

The taps from the booster winding to the collector rings follow the same rules as applied to rotary converter armature collector ring taps.

In the tabulated winding data given in the table on page 125 for the winding shown in Fig. 11, the ring number is given before the rotary slot number as this ties the winding to the rings through the booster. At the top of this tabulation are given the data for taps to rings at the rear end of the booster winding.

Fig. 12 shows a complete synchronous booster converter rotating element for a six-phase machine. The large armature with the commutator is the rotary winding; the small armature has the booster


A

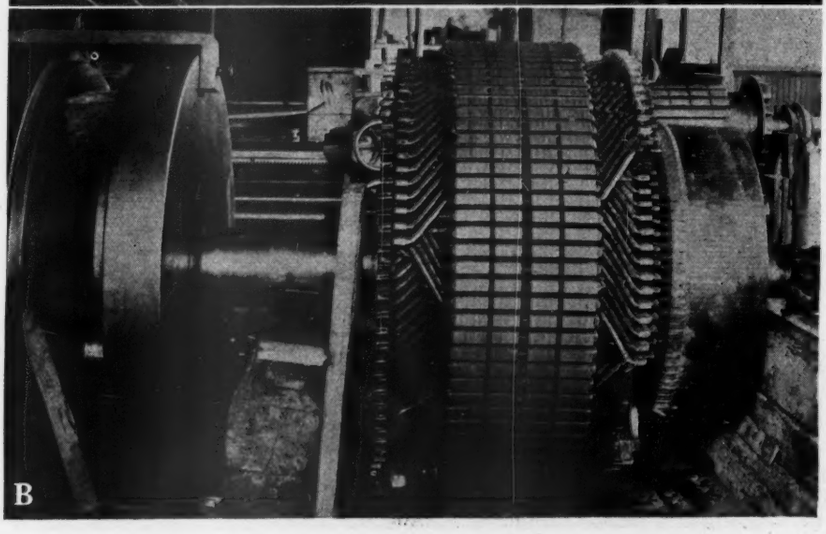

B

Fig. 13—This is a special duplex, six-pole, four-circuit wave, singly-reentrant, retrogressive winding.

winding. Note the taps between the rotary and booster windings.

From the above it is obvious that too much stress can not be placed upon the importance of getting the proper relation between the booster and rotary armature windings. This can be done by locating the keyway, then the slots on a line with it, and then working back to a tap from the rotary to the booster.

In what follows information is given for a special duplex, six-pole, four-circuit wave, singly re-entrant, retrogressive winding. The top layer of conductors is shown in Fig. 13*A*, There are four conductors per slot, the top (No. 1) conductor being connected to a bottom conductor (No. 4) in a slot one coil pitch (13 slots) away by means of a special connecting clip. Conductors No. 2 and No. 3, in slots 1-and-13 apart, are connected together, the connection being made inside of the top and bottom connecting clip as shown in Fig. 13*A*, thus making two windings of the two-layer, diamond-shape type, one inside the other.

The armature is shown in Fig. 13*B* with the top layer of conductors removed. Note how the bottom conductor (No. 4) is connected across the front to conductor No. 3, and a connection made from their junction to the commutator. Also note that conductor No. 2 connects to conductor No. 1 across the front and a connection is made to the commutator from this junction, thus forming two layers of a two-layer winding at the front end. The start of the series of three coils can be traced around the armature in Fig. 13*B*.

Figs. 14 and 14*A* show the complete series. Starting at bar *1* (at the left in the diagram) which connects to the top conductor in slot *1*, we cross to slot *14*, conductor *4* or the bottom conductor across the rear, then from slot *14* conductor *4*, to bar *53*, to slot *27*, conductor *3*, across the rear of slot *40*, conductor *2*, then to bar *105*, to slot *53* conductor *1*, to slot *66*, conductor *4*, across the rear, then out to bar *157* which completes a series of three coils.

The data given in Fig. 14 are sufficient to lay off the winding but the data in the table furnish an interesting study of this type of winding.

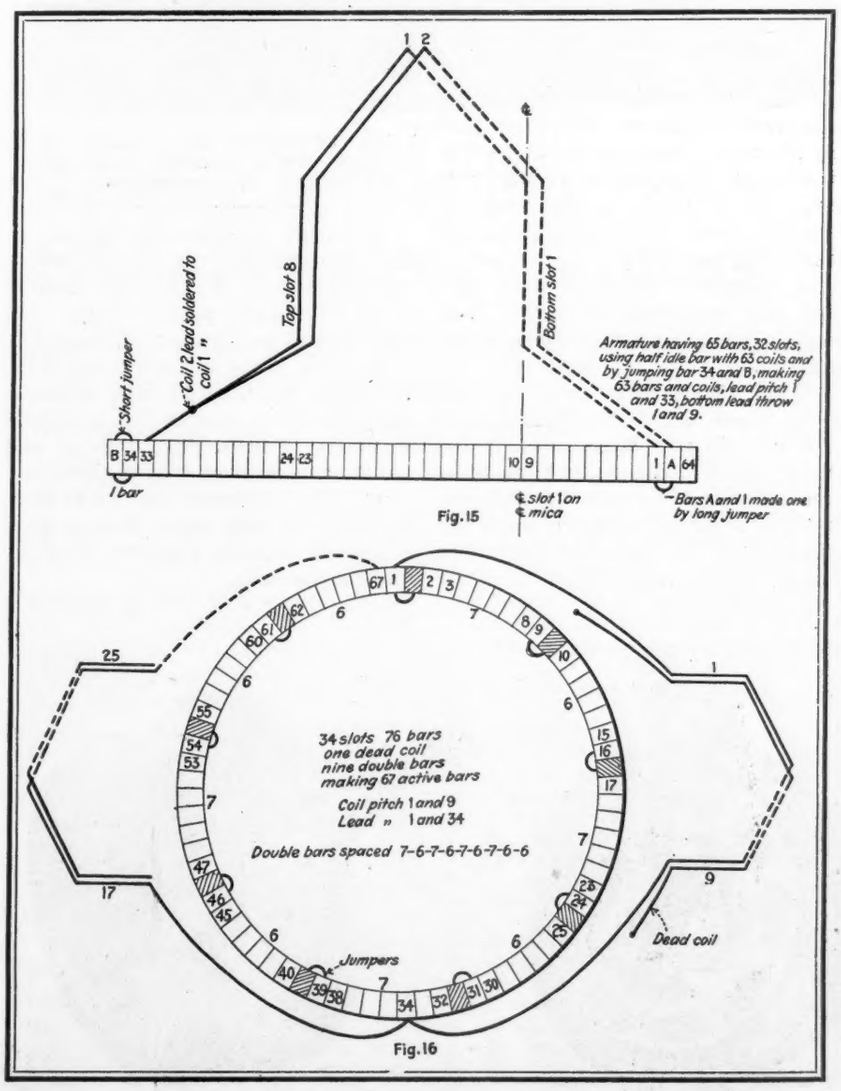
In Fig. 15 are shown the winding data for an old type of motor that would give trouble to the average winder. This armature has 32 slots and 65 bars, and since there are only 2 times 32 or 64 single coils, there is one bar too many. The 64 bars will not connect into a single-series wave winding, but 63 bars will, since 63 plus 1 will give a lead pitch of 32, or 1-and-33. This means that by using a half-idle coil as shown, one bar will be used up and by jumping bars *B* and *34* and making them one, the number of active bars is reduced to 63.

Another odd type of winding is shown in Fig. 16. This armature has 34 slots and 76 bars or 9 bars too many, since there are 2×34=68 single coils and 68 bars will not form a single wave winding. Therefore, there will be one dead coil making use of a total of nine bars. These are used up in the manner shown in Fig. 16 by jumping bar *1* to the adjacent bar and considering these as one large bar. This is done at bars *9*, *16*, *24*, *31*, *39*, *46*, *54*, and *61*, which spaces the jumpers fairly even. In counting off the lead pitch or lead throw, the jumped bars must be counted as one bar. The series of two coils illustrates this fact.

On machines of any type that have interpoles, a careful check of the armature winding data should be made and particular attention paid to the alignment of the commutator bars with reference to the center line of the keyway when the commutators are removed for repairs, or when new mica segments are used.

When interpole machines are tested at the factory the end bracket and brush positions are located on the dead neutral. On machines having fixed brushes the end brackets are doweled to the frame, thus establishing a fixed position for the coil and lead pitch. The bars in the commutator also have a fixed relation to the keyway in the commutator bushing, that is, the center line of the bar or mica on the center line of the keyway and also the

Figs. 15 and 16—Two types of windings that frequently give trouble to the winder.


Short jumper
Coil 2 lead soldered to coil 1
Top slot 8
Bottom slot 1
Armature having 65 bars, 32 slots, using half idle bar with 63 coils and by jumping bar 34 and B, making 63 bars and coils, lead pitch 1 and 33, bottom lead throw 1 and 9.
B 34 33 24 23 10 9 1 A 64
1 bar
℄ slot 1 on ℄ mica
Bars A and 1 made one by long jumper
Fig. 15
34 slots 76 bars
one dead coil
nine double bars
making 67 active bars
Coil pitch 1 and 9
Lead " 1 and 34
Double bars spaced 7-6-7-6-7-6-7-6-6
Jumpers
Dead coil
Fig. 16

center line of an armature tooth or slot, bears a fixed relation to the center line of the keyway in the armature punching. Also, both the keyways in the commutator bushing or spider and the armature punchings have a fixed relation, thus establishing a fixed relation between the center line of a coil, tooth, slot and bar or mica, according to the rules given above.

In dismantling a commutator and reassembling it without checking the relation of the bar to the keyway, there is a chance of throwing the neutral off. The greatest amount that the neutral can be shifted is equivalent to the chord of one-half the bar angle measured at the face diameter of the commutator or, in other words, one-half the width of one bar and one mica strip. The length of this chord or width of bar depends upon the number of bars and the diameter of the commutator, being greater with a small number of bars and a given diameter. That is, the chord length increases with a large diameter.

If a commutator has the center line of the keyway on the center line of a bar, then the most that the bar can be shifted would be to the position where the center line of the keyway lines up with the center line of the mica, which is a total shift of one-half bar. Changing the commutator alignment one-half bar, will affect the speed, causing a variation of 3 to 10 per cent in speed and also cause sparking and flashovers in some cases.

Figs. 17*A*, 17*B* and 17*C* show a tool or gage that has been developed to check the bar alignment with reference to the keyway. Fig. 17*A* shows a good view of the gage, which consists of two fixed arms at right angles to each other, the upright arm being attached to the shorter arm in such a manner that its inside surface is on the center line of a slot in the short arm. This slot carries a small dummy key that fits the keyway in the commutator bushing under test. The inside surface of the upright is thus on the center line of the keyway. This upright is slotted and carries an adjustable arm which is also slotted and has a pointer at one end. The surface of the adjustable arm that is in contact with the surface of the upright represents the center line of the keyway.

Fig. 17*B* shows the gage in place at the rear of a commutator and shows how the keyway center line is transmitted to the surface of the commutator.

Fig. 17*C* shows the top front view of Fig. 17*B*, which indicates that the center line of the keyway is on the center line of the bar.

From the above it follows that, when taking rewinding data, the keyways of the armature and the commutator, play an important part in all cases (none excepted). The rewinding data should be laid out with the keyways as the base or starting point of the data taking and recording operation.

A little time expended when taking and recording rewinding data will in the end prove a time-, labor- and material-saving proposition.

When taking data on a machine with which one is not familiar, do not cut off any leads nor lift too many coils, without first marking the core and commutator and also making a pencil sketch to show the relation of the disturbed parts. In other words, make a lot of haste very slowly.

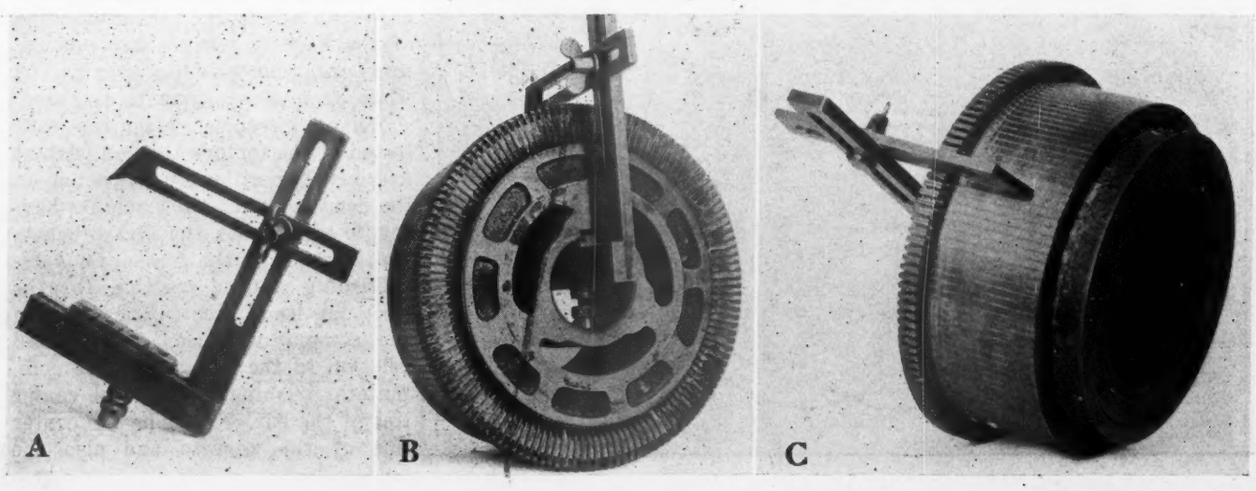
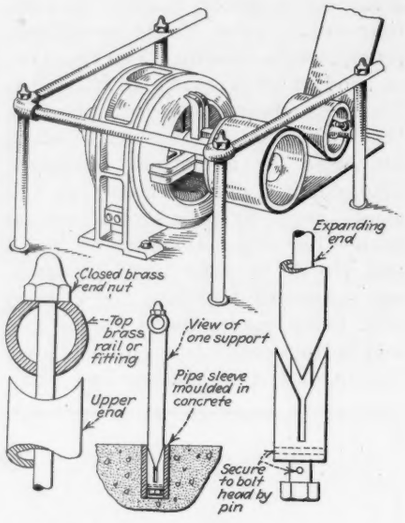


Fig. 17—This is a tool or gage that is useful in checking up bar alignment with reference to the keyway on a commutator spider.

Rigid But Demountable Rail Around Machinery

SOME form of guardrail is often essential around steam engines, turbines, motor-generators, motors and other machinery to protect employees or visitors around the plant. A demountable guard rail, which may be used for this purpose, is shown in the accompanying sketch.


Expanding end
Closed brass end nut
Top brass rail or fitting
View of one support
Pipe sleeve moulded in concrete
Upper end
Secure to bolt head by pin

The advantages of a guard rail which can be removed easily are obtained in this construction.

A feature of this construction is that although this rail is rigid when erected it can be removed easily. Also, no flanges project above the floor when the guard rail is removed.

The rail is set into sockets which are made up of short pipe sections cast into the concrete. The uprights are made of brass pipe, with an expanding member of special construction. The horizontal top rail is held securely by the same bolt which holds the vertical supports fast in the floor sockets.

Washington, D. C. G. A. LUERS.

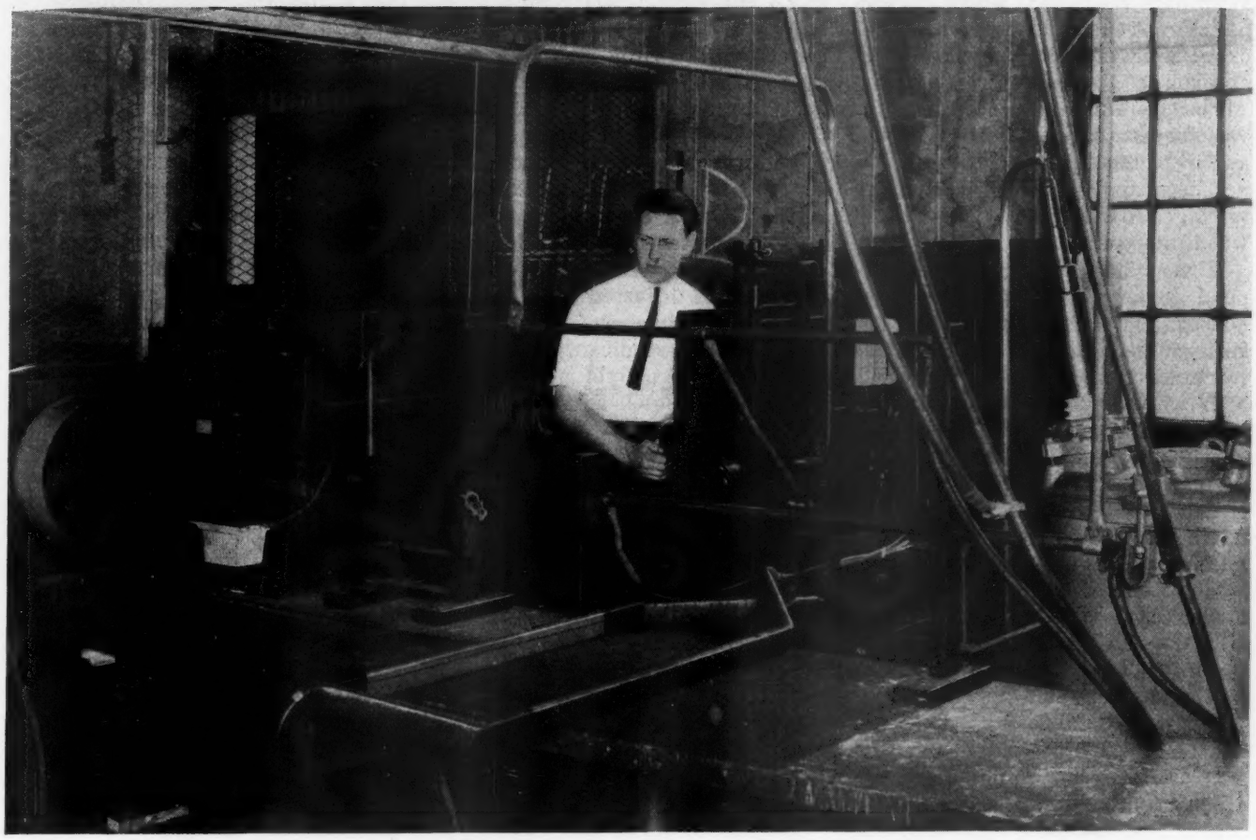


Fig. 1—A very high voltage can be applied to any winding without injurious current flow, if its frequency is sufficiently high.
The apparatus illustrated here provides high voltage having a frequency varying between 5,000 and 200,000 cycles per sec., depending upon the equipment under test.

Testing Insulation With High-Frequency Voltage

together with faults of present methods of testing and the scope of application and results obtained through the use of the new method

By J. L. RYLANDER
Electrical Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FOR MANY years the need for a higher test voltage between turns of individual coils or complete windings has been recognized. To obtain this higher test voltage, high frequency is now being used. How the high-frequency voltage is generated, applied to the apparatus under test, and the benefits obtained through its use are discussed in this article, which is an abstract of a paper delivered by Mr. Rylander at the Midwinter Convention of the American Institute of Electrical Engineers held last month in New York.

INSULATION is used on rotating electrical apparatus to insulate between the various parts which have a difference of potential and also to insulate all parts of the circuit from "ground." The "ground" insulation is thoroughly tested by the present method of applying a high potential, usually at normal frequency, between the winding and the core or frame at various stages of construction. The present methods of testing the insulation of various parts of the same circuit, such as from one turn to other turns, or one layer of wire to other layers of wire, are far from adequate.

The present method of testing consists of placing the coil over a pole piece magnetized by a primary coil which induces a voltage in this coil as the secondary coil of a transformer. The maximum voltage that can be induced by this method will not exceed 10 or 20 volts per turn in most coils, as the voltage is limited by the size of pole piece that can be inserted into the opening of the coil and by the frequency of the circuit. Usually 133 or 500 cycles per second are used. This test discovers short-circuits where there is actual copper-to-copper contact. However, it does not discover any weak or damaged insulation where there is not actual copper contact. Therefore, many coils are given no insulation test.

The windings of d.c. armatures are tested by this same induction method by revolving the armature slowly and testing each coil separately. This test discovers any short-circuits caused by actual copper-to-copper contact and also discovers open circuits. As this type of testing apparatus is only adaptable for rotating windings, induction motor primary windings are not given this test.

In order to obtain a higher test voltage, that would be considered a real insulation test, between turns of coils both before and after winding the coils in the machine, high-frequency voltage is applied directly to the terminals of the coil or windings.

With high frequency, advantage can be taken of the inductance of the coil or winding and thus obtain almost any voltage desired.

The use of high frequency for various test purposes is not new, but as far as the author is aware it has not been applied to the commercial testing of individual coils and of wound apparatus.

A very high voltage can be applied to any winding if the frequency is sufficiently high. The voltage drop due to the inductive reactance is $E = 2 \times 3.1416 \times f \times L \times I$, where f is the frequency in cycles per second, L is the inductance in henries, and I is the current in amperes. For example, a 15-turn circular coil with a 12-in. diameter having a d.c. resistance of 0.1 ohm and an inductance of 0.001 henry would have approximately the following voltages across its terminals with 10 amp. in the circuit: 1 volt, d.c.; 4 volts, 60 cycles per second, and 4,000 volts with 60,000 cycles per second. It is thus seen that practically any desired voltage can be placed across a coil or a winding if sufficiently high frequency is applied. The voltage is applied by connecting the two leads from the high frequency apparatus directly to the terminals of the coil or winding, either partially or completely finished.

When high frequency is applied to the apparatus under test, it sets up an alternating electromagnetic field of a particular frequency in a manner similar to a radio transmitter. If a short-circuit occurs in the winding, the wave length and frequency will be changed accordingly, and the strength of the outgoing signals is reduced. A wave meter is used to measure the outgoing waves and thereby determine whether any insulation failure has occurred.

The wave meter consists of a set of inductance coils, variable condenser with a vernier attachment, two variable resistances and a low-reading ammeter of the thermo-element type, all connected in series with one of the inductance coils. The inductance coils are such that by changing the setting of the variable condenser, resonance may be obtained for the frequency generated by the coil or winding under test. The condenser, the ammeter, and the variable resistances are mounted on a panel and a tuning coil is placed near the apparatus being tested. The tuning coils have low resistance and a minimum capacity for a given inductance. Coils with taps are unsatisfactory on account of the end-turn loss.

The wave meter is tuned to the frequency of the waves emitted by the apparatus under test and it acts in a manner similar to a radio receiving set. A current flows in the wave meter circuit which is measured by the ammeter. The variable condenser is adjusted until a maximum current is shown on the meter which thereby indicates the condition of resonance and also the frequency of the circuit. The meter reading alone does not mean anything in particular; it is the relative meter readings used in connection with the condenser readings and the distance from the tuning coil to the apparatus under test which tell the story.

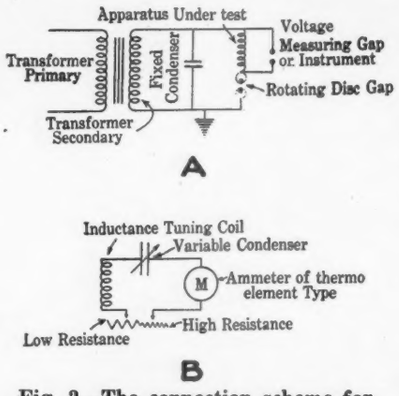


Fig. 2—The connection scheme for the equipment producing high voltage is shown at A.
Diagram *B* shows the connections for the apparatus used to detect the presence of short-circuits or other defects in the winding under test.

The principle by which high frequency is produced by this outfit is that a condenser placed across the secondary terminals of the transformer is charged during each alternation of the 60-cycle current. The condenser is automatically discharged through rotating disks when the voltage reaches a predetermined value on each alternation. The discharge of the condenser through the apparatus under test produces a high-frequency current whose frequency is determined by the apparatus under test and the capacity of the condenser.

The high-frequency testing apparatus for commercial use consists essentially of, (1) equipment for generating the high frequency and applying it to the apparatus under test, and (2) a means of detecting any short-circuits or failures in the insulation of the apparatus under test while the high frequency is being applied. An illustration of the apparatus is shown in Fig. 1. A schematic diagram of the connections is given at *A* and *B* of Fig. 2, Fig. 2*A* showing the generation of the high frequency and its application to the coil or winding and Fig. 2*B* showing the apparatus used in the detection of an insulation failure.

The power is furnished by a transformer of 10-kw. capacity with 7,500/15,000 and 30,000 volts on the secondary. A 70 per cent reactance limits the current to one and a third times full-load current with the short-circuit current in the secondary. The condensers have a capacity of 0.05 microfarads at 30,000 volts. The air-gap for discharging the condenser is formed between two motor-driven, rotating, brass alloy disks so that the arc across the gap will not burn the metal. The sphere-gap limits and measures the voltage across the apparatus under test. A resistance of 15,000 ohms is placed in series with the sphere-gap to prevent the spheres from being burned by the arc. For voltages of 5,000 and higher, 5-cm. spheres are used, and for lower voltages 1-cm. spheres are used, also instrument measurement. A panel contains switches for the circuit breaker and plugs for tapping in different values of reactance. A handwheel is used for controlling the spacing of the gap of the rotating disks. Voltages ranging from 2,000 to 30,000 volts can be obtained with this particular apparatus. By a combination of series and parallel connections the transformer will give 7,500, 15,000 or 30,000 volts; intermediate voltages are obtained by adjustment of the rotating gap.

The manipulation of the test apparatus consists of connecting the leads to the coil or winding under test and setting the sphere gap for the value corresponding to the desired test; then closing the circuit breaker and opening up the rotating disk gap until the desired voltage is obtained. This is indicated by a spark across the measuring gap. The voltages are generally applied for 10 to 15 sec. The frequency is determined by the apparatus under test usually within the limits of 10,000 to 200,000 cycles per sec. for individual coils and 5,000 to 100,000 cycles per sec. for wound apparatus.

The damped, high-frequency voltage as produced by this set gives a somewhat more severe test on the insulation than a corresponding

voltage at normal frequency. Fortunately such a test can be used to discover faults without damage to the normal insulation.

In general, the voltage builds up somewhat on the end coils. At first thought this may seem to be a disadvantage, but in actual service the end coils of a group are subjected to greater voltage in the case of surges than are the other coils. The voltage on the inner coils is sufficiently high, however, to give an adequate test for defects in material or workmanship.

The high-frequency, test voltage applied to the terminals of wound apparatus corresponds closely to the regular ground test as given by the Standards of the American Institute of Electrical Engineers. This allows a liberal margin of safety over the strain due to operation at its normal voltage, and also to the momentary high-voltage, high-frequency surges that may be impressed in service.

The voltage which it is desirable to apply to individual coils before winding into a machine is largely a question of judgment based on experience. We have used successfully on induction regulator coils a test voltage on single coils somewhat higher than the operating voltage of the machine for voltages lower than 2,500 volts, while for voltages over 2,500 a test voltage somewhat lower than the operating voltage was used.

The methods used for various types of apparatus are somewhat different, depending on various conditions. The method of testing a single coil is shown in Fig. 1.

The method of testing the windings of a two-pole, single-phase induction regulator is shown diagrammatically at *I* of Fig. 3 for the stator and at *II* for the rotor. The two leads from the high-frequency set are connected to leads *A* and *B* of one pole and the tuning coil of the wave meter is placed alongside the frame as shown at *C*. The voltage is applied for 10 to 15 sec. The two high-frequency leads are then connected to the leads *E* and *F* of the other pole of the winding and the tuning coil placed at *G*.

The high frequency leads can be connected to three-phase machines by the methods shown at *III* to *VI* of Fig. 3. The high-frequency leads may be connected across each pole-phase group as shown at *V*, from each lead to the star connection, as illustrated at *VI*, or across the leads, as at *III* and *IV*. Each of these connections has merits for certain conditions as determined by the number of poles, the voltage of the machine, the number of turns in the winding, the number of parallel connections and the size of the machine.

On a d.c. armature the voltage is applied at two points on the commutator corresponding to the location of the brushes, and the armature is then rotated.

The tuning coil of the wave meter is placed in the most advantageous position, which usually is close to the outside circumference of rotors and either inside the bore or outside the frame of stators.

For each coil and winding the wave meter settings are recorded. These settings show both the frequency and the strength of signal transmitted from any particular apparatus when the winding is normal and free from faults. As each coil or winding is tested, the readings will correspond to the standard readings if the winding is free from faults, but if short-circuited, different readings will be obtained. It is thus easy to check any apparatus that has been previously tested. If new, the approximate readings can usually be estimated with sufficient accuracy by comparing the general characteristics of the windings with other known windings, and checking one part of the winding with another is an additional check. The fact that a short-circuit has a deadening effect on the radiations transmitted as well as changing the wave front length and frequency, facilitates the discovery of any short-circuits.

This method of insulation testing was first applied commercially in the testing of induction regulator coils. The results were so satisfactory that the test was extended to the wound regulators, both stators and rotors of single-phase and three-phase machines of all voltages up to 14,000 volts and hundreds of wound primaries and wound secondaries are now being tested each month with high frequency. The development has now reached a point where completely wound d.c. armatures, turbo-generator coils, and wound induction motors either partly or completely connected have been tested experimentally. Considerable experimental work must be done before this method can be applied safely as a commercial shop test to complete windings of large alternators or induction motors. For example, sufficient information as to satisfactory test values is not yet available to apply high-frequency voltage, as a test to the complete windings, which will be a proper measure of their ability to withstand surges during operation.

Testing coils and windings with high frequency has given valuable information on the insulation of the apparatus to which this test is applied. For example, it has shown that insufficient insulation for reliable operation was used in some cases; that different kinds of material should have been used in others; that certain insulating materials have been badly crushed during one of the coil-forming operations; that the vacuum impregnation has not fully penetrated to all parts

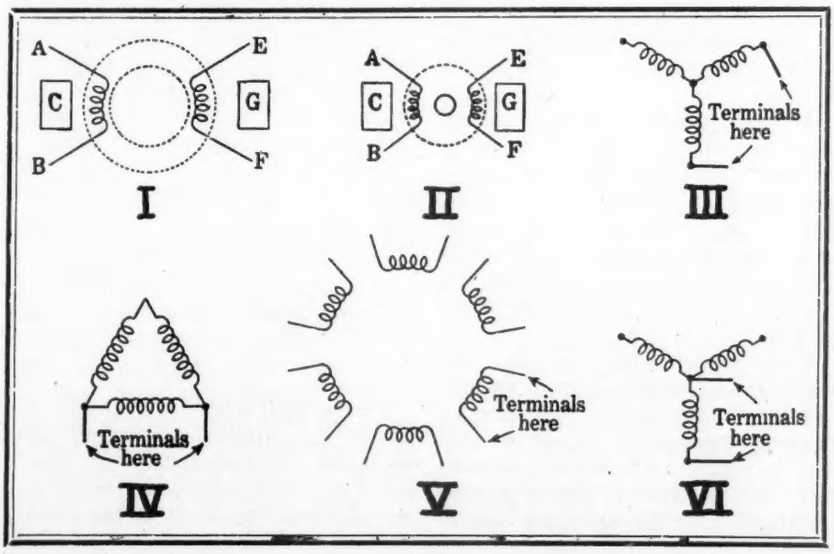


Fig. 3—Methods of applying the high-frequency voltage to various types of windings.

Diagrams *I* and *II* show the method of testing the stator and rotor of a single-phase induction regulator. Diagrams *III* to *VI* inclusive, show the testing methods for three-phase induction regulators having various connection schemes.

of the coil, and that the moisture has collected in these spots; and that the insulation used on certain designs was too liberal. It has also furnished a good idea as to whether the insulation was sufficiently balanced between the various turns and layers to withstand the natural uneven voltage distribution that occurs in coils and windings whenever the windings are subjected to surges and line disturbances.

Consequently, it is seen that high-frequency testing has made possible the improvement of the insulation of the windings by eliminating weak or defective coils, which might otherwise have been used. High frequency also checks the ability of the insulation to withstand the occasional severe dielectric strains that will occur in service and to which at present so many of the otherwise unaccountable insulation failures are attributed.

As induction regulator coils have been tested regularly for over four years some of the results of these tests will be of interest. During the first two years, 5 per cent of all coils tested failed to stand the prescribed test but the weekly percentage of failure varied from 1 per cent to 30 per cent. During the past year the percentage failures varied from 0 to 2 per cent weekly, with an average of 1 per cent. This great reduction in the number of coils that failed to stand the test was accomplished by correcting the cause of the trouble, which can usually be determined by a thorough, painstaking examination.

However, if these coils had not been rejected on account of the high-frequency test, all of the coils would otherwise have been used, as none of the coils had any defect that could have been discovered by any other method than the use of high-frequency voltage testing.

A record of the complete windings that have been tested shows that out of 100 machines of a certain particular type there were no failures, but on other types there were as high as 10 per cent and an average of 1 per cent for all types. It is not to be inferred that the faults detected by this test would all have resulted in service failures. The applied test has purposely been made severe in order to certainly weed out all weaknesses of this class.

There has been a distinct improvement in these machines from the service standpoint. Whereas, there was a considerable number of failures, before high-frequency testing was started on these coils, there has not been reported a single insulation breakdown in service of any machine on which the high-frequency test had been applied to the coils or the winding.

High-frequency testing shows up poor workmanship, checks the insulation design and the processes of manufacture. It insures that proper and adequate insulating materials are in their proper place and not missing or damaged and that no harmful foreign materials are present therein.

It checks up such features as the elimination of moisture and the thoroughness of impregnation, undue mechanical pressure at any point and the ability of the materials to stand the mechanical operations of coil construction, and whether the various materials are sufficiently uniform.

All of the above conditions may exist but they may not be detected or discovered without the aid of high-frequency testing as they are hidden from view and consequently visual inspection does not reveal any imperfections.

One real merit of high-frequency testing is that it invariably shows the cause of the failure, as the arc is of only such intensity as to burn out the weak insulation without burning the copper. When a machine fails in service the opposite nearly always occurs, as the copper is usually so badly burned as to destroy all evidence of the cause of the insulation failures.

Comments on "Compensators and Primary Resistance Starters"

I HAVE been much interested in the symposium discussion on "Operating Characteristics of Compensators and Primary Resistance Starters" for starting squirrel cage motors, which appeared in the January issue of INDUSTRIAL ENGINEER. It is very easy to argue in favor of either compensator or resistance starter from the standpoint of electrical characteristics, and each has certain legitimate, although more or less theoretical, advantages which can be claimed for it.

However, a point which has been overlooked by all but one contributor, and barely suggested by him, is the reliability of the apparatus and the ease with which it may be placed in service again after a breakdown, by either temporary or permanent repairs.

In this respect primary resistance starters, whether of the so-called "compression" type, the grid type or the wire or ribbon wound type, possess a considerable advantage over the compensator, particularly where continuity of service and reduction of length of shutdowns are important.

Compensator coils do burn out more or less frequently from various causes, as the writer has learned from sad experience. About the only way to repair a burned-out compensator coil is either to rewind it, material and labor for which are seldom at hand, or to replace it with a new coil, which usually must be obtained from the manufacturer's warehouse and often from his factory. Any of these procedures involves a delay of from several hours to several weeks, as I likewise have cause to know.

Resistance starters, on the other hand, not only very seldom burn out (any failure being usually due to mechanical damage), but if the resistance unit does open it is a comparatively simple matter to patch it until new parts can be obtained. If cast grids are used they can be wired or clamped together; if a wound resistor burns open, repairs can usually be made by bridging the break, while there are several methods available for repairing the carbon disk type. Any of these repairs can be made in from a few minutes to a few hours at the most. The cost is correspondingly small.

Often continuity of service outweighs the small difference in efficiency which may exist between the two general types of starters.

LOUIS D. MOORE.
Formerly Electrical Engineer, Missouri Pacific Railroad Co., Kirkwood, Mo.

* * * *

I have read with considerable interest the article concerning the operating characteristics of compensators and primary resistance starters that appeared in the Janu-

Comparative Data on Starters for a 10-Hp., 220-Volt, Squirrel-Cage Motor

	Using 67 per cent of Line Voltage for Starting		Using 80 per cent of Line Voltage for Starting except in case of Across-the-Line Starter		
Class No. of starter	8605	8547	8605	8547	
Type of starter	Compensator	Primary Resistor	Compensator	Primary Resistor	Across-the-Line
Full-load current	29	29	29	29	29
Current inrush at line voltage	174	174	174	174	174
Starting voltage—per cent of line voltage	67	67	80	80	100
Starting torque—per cent of full-load torque	78	78	112	112	175
Line current at start—amp.	78	116	111	139	174
Size of starting fuses—amp.	60	90	90	110	150
Size of conductor required	No. 6	No. 4	No. 4	No. 2	No. 1

ary issue of INDUSTRIAL ENGINEER.

The difference between the two types of starters is very clearly brought out, but there is one point in regard to their practical application that has not been mentioned. With the primary resistance starter, it is usually necessary to provide heavier conductors for the supply circuit, and install larger fuses to take care of the greater current required in starting. This point can best be illustrated by comparing an I-C Class 8605 automatic compensator with an I-C Class 8547 primary-resistance type automatic starter. The comparative sizes are shown in the accompanying table which has been made up for a motor rating of 10 hp., 220 volts, three phase, 60 cycles.

Data are given for a starting voltage of 67 per cent of line voltage, in the first two columns of the table, and for a starting voltage of 80 per cent of line voltage in the next two columns.

With regard to the starting voltage in ordinary use I believe that the 67 per cent tap on compensators is satisfactory for over 90 per cent of ordinary applications. It is the practice of the Industrial Controller Company to connect all compensators on the 67 per cent tap for standard use, and it is very seldom that we ever hear of the necessity for changing to a higher voltage.

It is true that, if the comparison is made on the basis of 80 per cent of line voltage for starting, there will be less difference between the compensator and the resistance starter, although even in this case the current drawn from the line would be 25 per cent greater in the case of the resistance starter. Under these conditions, however, neither starter would meet the usual power company requirements as to allowable starting current, which places them on an equal basis.

From a practical standpoint it would seem that when the operating conditions are such that a motor will not start until 80 or 85 per cent of line voltage is applied to the motor terminals, the compensator or resistance starter might almost as well be discarded and the motor thrown directly across the line. As a matter of interest, however, it might be worth while to make a comparison showing fuse and conductor sizes for the two types of starters connected on the 80 per cent taps, comparing these also with a starter of the across-the-line type. This comparison is drawn in the last three columns of the accompanying table.

So far as the user is concerned, the most important factor to consider in determining which type of controller is to be used is the question of torque required and the line current permitted by the power company. After this point is decided the most important consideration is the mechanical design of the controller itself, as either type of starter will, of course, operate satisfactorily. We believe that, from a practical standpoint, the questions as to line voltage disturbance, power factor during starting, and power loss in starting, can be disregarded.

There is, however, one application where the transformer type of starter has the advantage over the primary resistance type, due to less power loss in starting. This is where the starter must be made dust tight and where ventilation is not practicable. The losses in the transformer are so small that no difficulty is experienced with dust-tight enclosures, but with the resistance type starter some ventilation is usually necessary in order to dissipate the heat developed.

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Industrial Controller Co.,
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Specifications for Lubricants

(Continued from page 117)

this year or next, that brand will have the same viscosity, flash and fire, specific gravity, cold test and other tests. Specifications are the oil refiner's guide in standardizing the production of his plant so that he can produce, year after year, the oils that he has found to be successful in meeting conditions in actual operation. They are the oil refiner's insurance that his product is of a certain quality and has certain characteristics.

Oil specifications mean much to the refiner of lubricating oils. Service is the specification that means much to the user of lubricating oil. Practically all manufacturers of lubricants have made a close study of the problems of lubrication in industry and are equipped to offer service and advice, which is based on a wide experience with industrial operating conditions, in the choice and application of lubricants to the particular problems of a plant.

Purchasers and users of oils in industrial plants would do well to acquaint themselves with the various specifications and the tests that are made in order to determine those specifications, if for no other reason than to be able to give them their proper weight, and no more, when they are buying lubricants, or making recommendations, or endorsing recommendations to solve the lubrication problems of their machinery or equipment.

A discussion of the various types of equipment and devices for applying lubricants under different industrial operating conditions will be taken up in another article of this series to appear in an early issue of INDUSTRIAL ENGINEER.

EDITOR'S NOTE: Special acknowledgment is made to the Vacuum Oil Co., New York City, for valuable information and assistance in the preparation of this and previous articles. Other companies who have co-operated are: Dearborn Chemical Co., Chicago, Ill.; Jos. Dixon Crucible Co., Jersey City, N. J.; Keystone Lubricating Co., Philadelphia, Pa.; Marland Refining Co., Ponca City, Okla.; The Pennzoil Co., Oil City, Pa.; Riehle Bros. Testing Machine Co., Philadelphia, Pa. (oil and bearing testing apparatus); Standard Oil Co. of Ind., Chicago, Ill.; Superior Flake Graphite Co., Chicago, Ill.; C. J. Tagliabue Mfg. Co., Brooklyn, N. Y. (oil testing apparatus); The Texas Co., New York City; Waverly Oil Works Co., Pittsburgh, Pa.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Managing Editor*

If You Show Appreciation for Good Work You Will Get More of It

RECENTLY an executive who has made an unusually rapid advancement from the ranks to the Vice-Presidency of an internationally-known institution was introduced at a dinner by one of his former superiors with the remark, "One of his outstanding characteristics is his practice of always giving the other fellow credit when he has done a good job." He might have added that this practice has unquestionably been an important factor in the success of many an executive.

Appreciation may be defined as a just valuation or proper estimate of worth or merit. It does not necessarily signify payment of money for services rendered. The reward may only be a handshake or a word of praise, but its value to the recipient is usually out of all proportion to its cost.

It is not an easy matter for anyone to do his best, month in and month out, and for most of us it is particularly difficult to keep up the necessary interest and sustained effort when there is a feeling that no one knows or cares whether we are doing our best.

Most successful executives have learned that a few words of appreciation for work well done are exceedingly effective in securing results in the way of loyalty and efficient service, that would be difficult or impossible to obtain by any other means.

Do Not Overlook the Valuable By-products of Maintenance Work

MOST of the benefits that accrue from proper maintenance attention to equipment are well known. Some of the incidental benefits, by-products, as it were, may not be so apparent or well recognized. On this point two of the maintenance executives who discussed their problems in the February, 1926, issue of INDUSTRIAL ENGINEER made interesting comments. For example, Hugo Slivinski, Master Mechanic, Deering Works, International Harvester Co., said:

> Whenever a machine is taken down and repaired or overhauled, it is always given a coat of paint. This freshens up the machine and the operator looks on it more as he would a new machine and so gives it better treatment.

Again, W. W. Lankton, Asst. Electrical Engineer, Detroit Copper and Brass Rolling Mills, had this to say:

> The curve drawing meter also has a peculiar psychological effect. Whenever it is being set up on a motor-driven machine, the operator almost invariably goes over his machine very carefully, oiling all parts and looking over belts and pulleys. In some cases of overloads, the trouble is immediately rectified in this manner.

Even though it is oftentimes necessary to make operators responsible for oiling and otherwise taking care of their machines, it can be assumed that in many cases these men are not particularly interested in this part of their work. This indifference, combined with more or less ignorance, is likely to result in neglect of the equipment, in the absence of some outside stimulus. The management must supply this stimulus and can do it most effectively through the medium of a well-organized maintenance department. If the plant owners or management do not care enough about the equipment to take the proper care of it, operators can hardly be blamed for adopting this same attitude and neglecting their machines. Neglected equipment spells low output, poor quality of work and, usually, low wages, all of which make for low morale.

The work that the maintenance department does in keeping the wheels turning is worth all it costs, and more. In addition, the by-products alone of this work merit all of the support and encouragement that you can give to the maintenance department.

What "Rating" Means and How It Should Be Considered

MISUNDERSTANDING of how to use properly the manufacturer's rating of equipment is often one of the important causes of dissatisfaction with the service rendered. Ordinarily the general or nominal ratings as listed by the manufacturer are intended only as a general guide, and are not always suitable for promiscuous selection and application. However, the prospective user needs a guide to indicate the various sizes of units available. As a general rule, the manufacturer rates his equipment at the highest safe figure obtainable under practically ideal operating conditions. Service or operating factors are then set up by which the rating is multiplied to give a new capacity or rating to take care of unusual conditions. This, of course, calls for equipment of increased nominal rating or capacity if satisfactory service is to be expected.

A common mistake of the prospective user is to neglect to take into account the fact that he has unusual conditions which require the use of a service factor. This is particularly true in connection with the mechanical apparatus used in power transmission. It is not uncommon to find chains, clutches, couplings, speed reducers, variable speed drives and other devices of standard rating attached to a heavy-duty or over-rated motor. The user then condemns the mechanical element if it does not stand up under the heavy service conditions.

Service ratings are as necessary as the primary ratings of equipment. Any manufacturer of either electrical or mechanical equipment welcomes the opportunity to advise a user from his experience on the allowances which should be made in the selection of equipment for any particular service.

Do Not Leave the Care and Operation of New Equipment to Chance

EVERY operating man is familiar with the inertia incidental to the acceptance and adoption of new ideas, methods or equipment. Many have also found that after a new piece of equipment is adopted for use, perhaps after a good deal of argument, it frequently happens that those who have it in charge do not understand or appreciate its value enough to take the proper care of it.

An interesting example of this was found recently in one plant. The plant engineering department had installed roller-bearing lineshaft hangers in a new addition. The oiling of these was left to the supervision of the production department foreman. During all of his years of experience, lineshafts had always been oiled every day. He could not comprehend that the new bearings required attention only at long periods and so compromised by instructing his oiler to oil them once a week. As the oiling was done while the shaft was in operation an excess of oil was poured in, only to run out again when the shaft stopped. This necessitated adding 2-qt. containers to catch the overflow.

Many plants are getting over these difficulties with new equipment which is not thoroughly understood, by having the engineering or operating departments take over its care until it is well broken in and the best methods of oiling, inspection, and control have been demonstrated by practical operation to the satisfaction of everyone concerned. Then there is little excuse or opportunity for trouble.

Standardize the External Dimensions of Mill-Type Motors

MANY attempts at standardizing industrial motors have been made, all of which have failed for various reasons. From the standpoint of the user, standardization cannot come too quickly. But from the viewpoint of the manufacturer, changing so as to meet certain standards which would not improve the performance of the motor, existing designs that have been evolved at great expense, would impose a hardship that manufacturers are undoubtedly justified in opposing.

At the present time, however, conditions have changed regarding one type of industrial motor. It is now generally understood that manufacturers are about to redesign their lines of mill-type motors, which are used extensively in steel mills. The time is, therefore, ripe for undertaking a standardization program for this type of motor.

A movement sponsored by the Association of Iron & Steel Electrical Engineers is now under way for standardizing such external dimensions of mill-type motors as will give interchangeability of motors of a given rated capacity. This Association is asking manufacturers to standardize on the following items: (1) horsepower ratings and speeds; (2) armature bearing dimensions, particularly if ball or roller bearings are used; (3) maximum external dimensions; (4) mounting bolt-hole dimensions; (5) shaft diameters; and (6) shaft tapers, keys, and keyways. With all of the manufacturers standardizing on these features it is expected that each manufacturer's mill-type motor will be interchangeable as a unit with any other manufacturer's mill-type motor of the same capacity.

This is a program that deserves the whole-hearted support of not only steel mill engineers and operators but also the operating engineers of all industries. Standardization, on the features mentioned in the foregoing, will reduce inventories of motors, bearings, armature shafts and pinions. It will enable all manufacturers to compete on equal terms on all jobs. It will make the operator's problem of spares a much simpler one and will increase the turnover of electrical stores and spare equipment. Efficiency and economy mark the operation of the plan throughout.

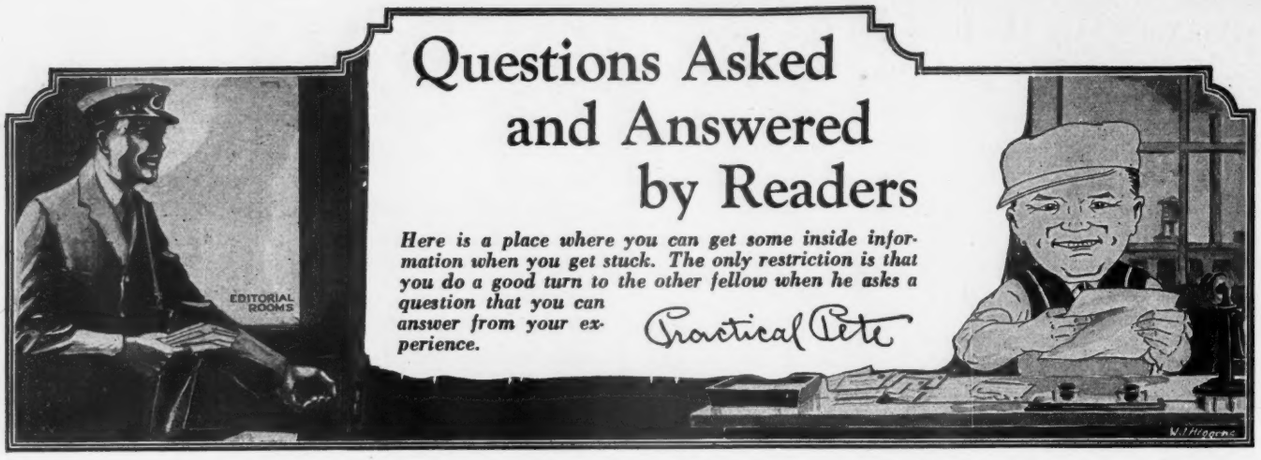
Moreover, this is the first decisive step towards the standardization of all types of industrial motors, a result that will be accomplished sooner or later, if there is an insistent demand on the part of industrial users. The Editors of INDUSTRIAL ENGINEER will be glad to have readers express their opinions on this subject.

Overvoltage on Lamps May Cost More Than You Realize

NO ARGUMENT is needed to prove that burning lamps at overvoltage shortens their life. That is a matter of common knowledge. It is also easy to see how the necessity for frequent replacement of lamps increases the cost of operating the lighting systems. There is, however, another item of expense which is likely to be overlooked: namely, the cost of replacing burned-out lamps. On this point Andrew Vogel, Plant Engineer, General Electric Co., made the following comments at a recent meeting of the Illuminating Engineering Society:

> It frequently costs more to place a lamp in a socket than the lamp is worth. When you are lamping fixtures at a height of 30 to 35 ft., or in some cases at a height of 50 to 60 ft., it is a rather expensive operation. Naturally, you want to keep your voltage just as constant as possible in order to obtain the maximum life from the lamp.
>
> In our design of wiring systems we design the copper to enable us to get a maximum of three watts per square foot at any point, or over any reasonable area. We have also designed our wiring installations so that the difference in voltage with one lamp on, or with all of the lamps in the section on, shall not be more than three volts. In other words, we do not adopt any arbitrary percentage of voltage drop. If the incoming line gives us the proper voltage we are going to get all of the usable life out of the lamp; we are going to get everything out of that lamp, from the standpoint of life and maximum efficiency, in every way possible.

Checking the voltage of the lighting circuits with a graphic voltmeter over a sufficiently long period to enable the variations to be determined, and study of your lamp replacement records, may point the way to a worth-while saving in the operating and maintenance costs of your lighting system.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Method of Marking Rubber Gloves.—I would appreciate receiving any information concerning satisfactory methods of marking linemen's rubber gloves which are periodically subjected to electrical tests, as I wish to mark on the gloves the date of the last test. These gloves are used constantly for both inside and outside construction work. Any help that readers can give me will be greatly appreciated.
Lowell, Mass. J. H. J.

* * * *

What Are the Comparative Advantages of Two-Point and Four-Point Adjustable Hangers?—I am planning on installing an additional section of lineshaft and would like to get the opinions of other readers about whether to use two-point or four-point adjustable hangers. What are the advantages of each from the installation, operation, and maintenance standpoints? Would these advantages be worth the difference in cost? This will be a 1 15/16-in. shaft, 50 ft. long. The present installations are all two-point adjustable hangers. Will other readers tell me what they would use and why?
Indianapolis, Ind. B. K. W.

* * * *

Heating of Commutator on Rewound Repulsion-Induction Motor—I recently rewound a G. E. single-phase ½-h.p. four-pole type RI 110-volt repulsion-induction motor and am having trouble with it on account of heating. The commutator seems to heat first and in about two hours the motor gets so hot that you cannot put your hand on it, and it keeps on getting hotter. It does this when running idle. I have tested the commutator, armature, fields, and bearings and they seem to be O. K. The armature is well balanced. I used No. 16 d.c.c. wire in the rotor and main field and No. 18 in the compensating field. I shall appreciate any information regarding the cause and remedy of this condition.
Hubbard, Ore. R. S.

* * * *

Changing 25-Cycle Brake Coil to 60-Cycle Service.—I am having a little trouble in changing over a brake coil from 25-cycle to 60-cycle service. This coil is used on the brake on the hoist motion of a 10-ton traveling crane. The coil was originally wound with about 1,400 turns of No. 21 magnet wire for 25-cycle service. I have rewound the coil using 800 turns of No. 15 wire, but the coil only lasted a few days before burning out, and it does not seem to have the lifting power of the old coil when used on the 25-cycle service. This coil was formerly connected across a 440-volt, 25-cycle power supply and will be used on the same voltage for the 60-cycle service. The diameter of the smallest turn is about 2 in. and the largest turn about 4 in. The coil is in reality a solenoid with a plunger working through the center of it. Can some reader tell me how many turns to use on this coil and what size of wire should be used in order that I may use it on the 60-cycle power supply?
Green Bay, Wis. H. B.

* * * *

Drying Out Direct-Current Motors.—One of our largest steel works was recently flooded, due to the breaking of a dam. About 500 direct-current, shunt-wound, 250-volt motors, ranging in size from 10 to 250 hp. have been under water for 10 days. Our problem is to dry out these motors in the shortest time. The greatest difficulty encountered is in drying out the shunt-field coils. Drying out in an oven is rather slow, due to the large number of motors that must be taken care of. I would greatly appreciate learning from readers what methods they would suggest for drying out these motors, particularly the field coils.
Bressoux, Liege, Belgium. P. V. H.

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Are Transformer Laminations Injured by burning off Oil and Insulating Compounds?—I will appreciate it if some readers can give me the following information: Does heating transformer laminations to remove the insulating compound and oil injure them? Is it standard shop practice to do this? How much will the iron loss be increased, if any, by this procedure? If the laminations are japanned after burning off the oil and compounds, will this cut down the core loss? Will an oxide form on the iron, during the heating, which will cut down the core loss? How hot may the iron be heated without injuring it?
Santa Ana, Cal. C. C. B.

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Trouble with Solder.—We are having considerable trouble in making soldered joints hold on rectangular wire in coils that are subjected to rather high temperature, such as might be the case in series field coils and brake series coils. We have tried an 80 lead—20 tin solder, but it melts due to the excessive heat. Can our readers suggest any methods that will enable us to join these wires together in a manner that will stand rather high temperature? I shall be very much indebted to any reader who can give me some help in this matter.
Norton, Va. W. H.

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Overload Protection for Generators.—(1) We have installed in our power plant, two 2,000-kva. generators and two 4,000-kva. generators all of which are rated at 2,300 volts, three phase, 60 cycles, 3,600 r.p.m., and are driven by steam turbines. What protection should we have on these generators? Should reverse power relays, or overload relays, or both be used? Are these relays necessary and also what other protection is required on these machines? The four machines are arranged to be paralleled together and quite often all of them are running simultaneously. (2) We have installed one 50-kw., 125-volt, motor-driven generator which operates in parallel with two 100-kw. steam-driven exciters for supplying field excitation for synchronous motors. Should we have circuit-breaker protection on these machines and if so, should a three-pole circuit breaker be used? I shall appreciate any information that readers can give me regarding these questions.
Detroit, Mich. R. J. B.

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Winding Rectangular Wire on Edge.—I would like some suggestions from readers on how to wind coils, using rectangular wire or ribbon. These coils have to be wound with the copper on edge. My particular problem is the mechanical operation of winding the thin copper strips on edge without using too elaborate a machine. To be specific, I desire to wind both a round and an approximately square coil, using 1/16-in. by ¾-in. copper ribbon. The diameter of the core of this coil should be 1 in. and in the case of the square coil, the side should be 1 in. I also desire to make up a coil around a 1-in. core using strip copper 0.01 in. by 1 in.
Bloomington, Ill. A. S.

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Answers Received To Questions Asked

How to Support a Mule Stand.—We are planning on a lineshaft installation in which it will be necessary for the shaft to extend across the room, with an additional section to be installed at right angles along the side wall. We have been considering using a mule stand but some of our men who have had experience with this device in other shops advise going to the expense of separating the shafts and using two motors.

I should like to know the methods other readers have used in supporting such stands and lubricating the pulleys and the results they obtained. This is a mill-construction building with a 2 15/16-in. main shaft and a 1 15/16-in. shaft on the extension.
Milwaukee, Wis. R. C. A.

I believe that R. C. A. has the choice of two methods of supporting his mule stand. The first is to extend the shaft up to a support such as a roof girder, ceiling beam, or the like. A bearing may be mounted at the top and bottom and clamped tightly to the shaft to keep it from rotating. Provision should be made so that the shaft can be moved slightly in any direction for alignment. The second method, which is necessary where an overhead support is lacking, is to brace the upper end of the shaft by means of four truss rods of heavy

construction. These should extend to the walls or floor.

However, I believe that a mule is undesirable as there are usually lubrication and belt troubles due to the fact that the space is cramped, which necessitates a short, tight belt. An idler still further complicates matters. Much the better method is to install a bevel gear drive. This has the advantage of requiring very little space, no overhead construction and slight attendance. A gear drive of the size given by R. C. A. would have one iron gear and one inserted, wooden-tooth gear.

A most important point is that if a ratio of, say, one to one is selected, and it need not be absolute, one gear may have say 100 teeth, while the other would have 99 or 101. This results in the teeth wearing more evenly and so giving more silent operation. It is possible to use any desired ratio but it is well to see that the number of teeth in one gear is not a multiple of the number of teeth in the other.

Chief Engineer, PHILIP N. EMIGH.
The Mountain Water Supply Co.,
Indian Creek, Pa.

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In answer to R. C. A.'s question about the practicability of using a mule stand for cross-shaft driving, I would say that he seems to have touched on the two most important points when he mentions the support and the lubrication. When properly installed and maintained there is no reason why that type of drive should not be satisfactory in every way; if, however, certain points are neglected the mule drive can be just as cantankerous and stubborn as its more famous namesake is credited with being.

The accompanying sketch shows one of many such drives which I know from experience are giving no trouble whatever and are almost noiseless in operation. The only attention required is to screw down the grease cups daily.

The main points considered in the layout and installation of this drive are its supports and lubrication. Figs. I and IV show how the mule stand is supported and braced. The arbor *a* is threaded into a 10-in. flange, *b*, which is bolted onto the bottom side of a 10-in. by 12-in. timber. Two guy rods, *c* and *d*, with turnbuckle adjustments are attached to the bottom of arbor *a* to counteract the belt pull. This might appear to be an unnecessarily heavy and rigid support for a light drive, but the worst enemy of the mule drive is vibration and the more vibration can be eliminated, the better the drive will operate.

The other important factor, lubrication, is taken care of in this particular drive by grease cups which force common grease into the end of a hollow shaft and out through small grease holes, as shown at *i*, Fig. II. The bottom of the pulleys, Fig. III, is finished as shown at *k* and is supported by the bottom *l* of the cup *m*; this cup also helps to retain the grease which is forced down through the hollow shaft and under the pulley by the grease cup above.

This method of lubrication is quite satisfactory for light drives. These sketches show a drive with a $2\frac{15}{16}$-in. main shaft and a $2\frac{7}{16}$-in. cross-shaft with a 4-in. belt. The mule pulleys operate at 600 r.p.m. For a heavy drive, however, where it is necessary to use a 10-in. or a 12-in. belt, roller bearings should be used on the shafts and ball-thrust bearings under the pulleys.

There are a few other points which will also make for satisfactory operation: one of these is to fasten a support, *h*, Fig. I, to the end of the arm *e* which carries the pulley on which the slack side of the belt runs when the load is applied. When this is not done a sudden load will often cause the belt to drop off, although it takes very little to support it.

It is also good practice, wherever room permits, to make the distances *n*, Fig. IV, between the centers of the pulleys and the centers of the driving and of the driven shafts, a number of feet which will be at least twice the width of the belt in inches; thus, for a 6-in. belt the distance between shaft centers should be 12 ft. The reason for this is that the belt is twisted one-quarter turn and if that quarter twist is taken in too short a distance the life of the belt will be considerably shortened and the drive will tend to give more trouble through vibration.

Belleville, Ont., Can. J. H. GALLANT.

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From my experience with a mule stand, I would strongly advise R. C. A. to drop the idea altogether especially for a permanent installation. If it is necessary to run one shaft at right angles to the main shaft by all means use another motor and drive this shaft independently. The saving in power alone will soon pay for the motor, to say nothing of the installation and maintenance costs of a mule stand.

It is very difficult to line up a mule stand so that the belt will run right on all four pulleys. There is no rule that can be applied; it is simply a matter of cut and try. Moreover, to lubricate the pulleys on the mule, it is necessary to shut down to fill or screw down the grease cups. The power waste is enormous and the best belt will not survive long when used over a mule stand.

For very light power transmission, involving not more than 2 or 3 hp., a mule might be more practicable, but from the size of shafts named in the inquiry, I surmise that R. C. A. expects to transmit a considerable amount of power. GUY H. WINTERSTEEN.
Cleveland, Ohio.

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If R. C. A. remembers that the same rule applies to mule stands as to all other pulley practice, that is, that the belt must run in such a way that it will feed onto the pulleys in a straight line, he will have less trouble. Mule stand pulleys operate most readily if the same size pulleys are used on the driving lineshaft and on the driven lineshaft. It is, of course, essential not to use a pulley of a diameter too small for the weight of belt. The diameter of pulleys to be used on the lineshaft is immaterial.

Some industrial plant men prefer to use flanged pulleys on the mule stand, but this is not essential, and unless the pulleys are aligned absolutely the belt will wear on one or the other of the flanges.

One of the best methods of securing the mule stand, wherever possible, is to use two shafthangers placed horizontally on a heavy post. Where a post or a wall is not convenient, the shaft of the mule stand may be attached to the ceiling or floor by mounting one end in a cast iron socket or floor plate screwed to the ceiling or floor. The other end is braced by guy wires or cables preferably with a turn-buckle in them for taking up any slack and giving sufficient tension, so that the mule stand will maintain vertical alignment, even when the drive is operating under full belt tension. A mule stand must be erected very substantially or it may be pulled down in case the belt breaks, as was once experienced by the writer.

Elgin, Ill. SVEND E. SALOMONSEN.

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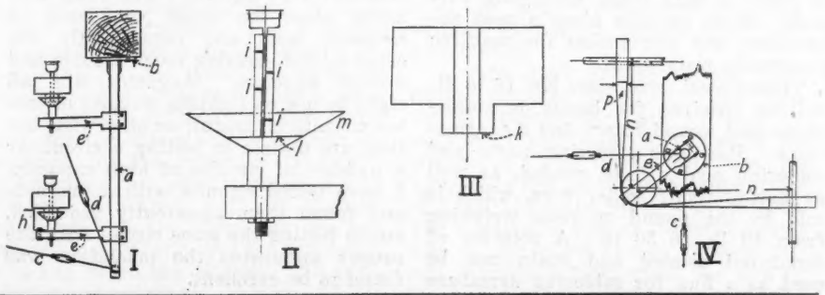
What Shop Equipment Will Be Required Here?—I would like to have some of our readers tell me what equipment they think will be necessary for a shop to handle a general motor repair business in a city having a population of 50,000. I wish to have as completely equipped a shop as is consistent with the amount of repair work that I may expect to do in a city of this size. Any recommendations as to kinds and makes of equipment necessary, will be very much appreciated. Also, I should like to know what kinds and amounts of supplies, such as insulated wire, insulation, varnishes, tapes, etc., should be carried in stock.
Pedro Miguel, Canal Zone. P. F. W.

Answering P. F. W.'s question, a great deal would depend upon the size and type of machinery used in this town, and whether the power supply is mostly alternating or direct current. I

Construction, bracing and method of lubricating a mule stand drive for a 4-in. belt with the mule pulleys operating at 600 r.p.m.



presume that it is alternating current. The average contracting shop for repairing motors, transformers, and control equipment is established in a building approximately 60 ft. by 80 ft.

Regarding the selection of equipment, the following suggestions are offered: He will need a lathe with at least a 9-in. swing, which will permit rotors or armatures of about 18 in. diameter to be handled. A grinder with fine and coarse wheels about 8 in. in diameter and a small power drill for taper-shank bits, with an adjustable, round shank for small drills, will be needed. Coil winding equipment which may be obtained with the motor attached is the most suitable because there are no line-shafts or belts to install. At least one taping machine will be necessary. I would recommend the coil winding machine and attachments invented by S. H. Browning and manufactured by the Mutual Foundry Co., Atlanta, Ga. This company also makes a coil spreader. These machines are used by many electrical repair shops and are advertised in INDUSTRIAL ENGINEER.

For dipping and baking, a sheet-iron tank about 2 ft. deep, by 4 ft. wide and 6 ft. long, will be found suitable for this purpose, although the dimensions may be altered as necessary. I would recommend a ventilated oven about 6 ft. long, 5 ft. wide and 5 ft. high, built of brick or some other insulating material. This oven may be electrically heated, if gas is not available, or it may be either oil fired or steam heated, if desired.

Equipment for heating ovens with oil may be obtained from Hauck & Co., Brooklyn, N. Y. A monorail system with a 1-ton, chain hoist is almost a necessity. This monorail should extend the full length of the shop and be arranged so that it passes directly over the lathe, the dipping vats, right into the oven. A switch should be arranged so that motors can be handled from trucks at the doorway, or so that trucks can back under the monorail.

One or two armature racks should be built of 4-in. by 4-in., or 4-in. by 6-in. timbers, bolted together and well braced. A table of heavy material should also be built for supporting stators, while being wound. Both table and armature racks should have casters about 3 or 4 in. in diameter; smaller casters are a source of annoyance. The workbench should be provided with drawers for hand tools and should be well lighted both for night and day work, since there will be many overtime jobs on elevators and other important equipment.

The supplies needed will vary somewhat, depending on whether the equipment to be repaired is large or medium-sized, and also on whether the larger portion is a.c. or d.c. If the town of Don Miguel does not have an electrical supply house, the stock would probably have to be larger than ordinary. The following stock of tape will be required: 1-lb. rolls of ¾-in., friction tape; ¾-in., cotton tape in rolls about 3½ in. in diameter, for use on the taping machine and ¾-in., varnished-cambric tape in 3½-in. diameter rolls so that it may be used on the taping machine for high-voltage equipment. The thickness of the tape should be from 0.010 in. to 0.015 in.

Fishpaper is the most commonly used insulating paper and the untreated variety is the most flexible. The moisture content is only about 7 per cent, which can be reduced by heating the machine before dipping. The thicknesses generally used are 0.010 in., 0.015 in. and 0.020 in., which may be combined to obtain almost any thickness desired. A supply of fibre sheets 18 in. by 30 in. and of 1/8 in., 1/16 in. and 1/32 in. thickness will be needed for wedges and strips. Flexible mica, used for insulating transformers, molding mica, used for commutator cones and slip ring insulation, and commutator segment mica come in sheets approximately 18 in. by 30 in. and should be obtained in thicknesses of 0.020 in., 0.025 in., 0.030 in. and 0.035 in. Molding mica sheets 0.045 in. and 0.050 in. thick should also be obtained. An insulation cutter should be bought, as it will be found useful in cutting tin clips for bands and fastening coils before taping. It will also be found necessary in preparing insulation for closed slot stators and other equipment. Several sizes of cotton sleeving should be stocked and if d.c. or wound-rotor a.c. motors are to be repaired, various thicknesses of carbon and one or two sizes of pigtail wire will be needed for brushes.

Magnet wire will be an important item in your stock. It is made round, square and rectangular, which would make it impossible to stock every size and shape required; so the best thing to do is canvass the possible customers and ask permission to check up on their equipment. Obtain the horsepower and note whether d.c. or a.c., single- or poly-phase. Also note the temperature rating. Procure a wire gage and find the size of wire, from a stub, if the motor is of unusual design or size. The average a.c. or d.c. armature will have wire ranging from No. 9 round to No. 17 round. In small motors the wire will range from No. 20 to No. 33. Large stators and wound rotors sometimes have square, and in other cases rectangular, wires. In an emergency substitute round wire for this odd-shaped wire, but try to keep the circ. mil area the same, using the wires in parallel. Sometimes on a.c. windings the slot span can be changed to make up for the loss of copper. Copper bars can be reinsulated.

Paint is to the armature winder what putty is to the carpenter, "a friend in need." I prefer yellow or amber baking varnish for oilproofing; when the finished machine is removed from the oven, and is still hot, I spray or brush it with black air-drying varnish. Black varnish gives a neat appearance and also makes the machine practically waterproof.

Tinned steel wire, sizes No. 16 to 21, will be required for bands on single-phase and wound rotors and d.c. armatures. Burnley's soldering paste and soldering acid will be needed, as well as half-and-half solder wire, which is sold by the pound on reels weighing from 10 lb. to 50 lb. A solution of denatured alcohol and rosin can be used as a flux for soldering armature bands. Shellac gum is bought by the pound, or it may be purchased already prepared in one quart or larger containers. Amber shellac is best for all-around use. Glue should be bought in half-pint or pint cans, Le Page's glue is considered good.

P. F. W. will have to use his own judgment in selecting material, as he is familiar with the district in which he is located and knows whether he has any competitors, and their strength. He can also determine the amount of equipment installed in the town or district and from this determine what materials he should have on hand.

Birmingham, Ala. GRADY H. EMERSON.

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Misleading Results Sometimes Obtained from Magneto Test.—Sometimes I get rather misleading results through the use of a magneto to determine whether there are defects in some of our electrical apparatus. Under certain conditions I have found that the magneto will indicate a dead ground, whereas further investigation shows that the equipment is in very good operating condition. Also, I have found that a magneto will sometimes indicate an open in a shunt-field coil, when further investigation shows that the field coil is O. K. I should like to know if any readers have had similar experiences and can explain the reasons for this peculiar action of the magneto. Also, can you suggest other test methods that might be used under the conditions mentioned?

Omaha, Neb. M. P.

Answering M. P., the misleading indications to which he refers are the result of the alternating current produced by the magneto. If the equipment being tested has an appreciable electrostatic capacity, it acts as a condenser and permits the alternating current of the magneto to flow and thereby a ground is indicated even when the insulation resistance is high.

The false results indicated while testing shunt field coils are due to the inductance of such coils, which may be so high as to prevent the alternating current of the magneto from flowing, thus indicating an open circuit.

It is much better to use a direct-current source of supply for such tests. There is an instrument available known as the Junior Megohmer (made by Herman H. Sticht & Co., New York, N. Y.), which furnishes 110 volts direct current and is well suited for tests such as mentioned by M. P. The cost of the instrument is very little more than that of a good magneto. It has a range of 20 megohms and is, therefore, suited for many other tests which cannot be made with a magneto.

New York, N. Y. GEORGE O. POWERS.

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Answering the question asked by M. P. regarding the use of our old standby, the magneto, I would say that many place too much confidence in magneto tests and consequently are often misled, causing much trouble and useless expense. Magnetos are all right to use on lighting circuits or motor circuits in conduit or otherwise, but they are useless in testing a circuit or a number of circuits of high capacity. I have tested circuits with a magneto and found them apparently grounded, but in testing the same circuit with the proper apparatus the insulation was found to be excellent.

The best instrument any electrical repair gang can have around the shop is a megger. This does not necessarily have to be a large expensive outfit. The small megger in the aluminum case, put on the market by James Biddle, is very handy for all-around testing and will not give misleading results if properly used. Any good instrument of this type will be found to be worth many times its cost in an industrial plant of any size, especially one large enough to have electricians.

The megger can be used for making periodic tests on motors, starters and many other pieces of electrical equipment. If records are kept of these periodic tests on cards or charts where they can be referred to from time to time, many costly shut-downs may be averted because the condition of the equipment will be known in advance and may be repaired before it finally gives out, causing serious damage. If it cannot be repaired at the time, spare equipment can be made ready to take its place on short notice. An hour saved in many large industrial plants is well worth the price of any such insulation testing instruments.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co.,
Donnacona, Que., Can.

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Replying to M. P.'s question in a recent issue; nearly all magneto test sets generate alternating current. Since this is the case, the flow of current will not be limited by the ohmic resistance alone, but will be limited by the impedance of the circuit. The impedance of the circuit in ohms is equal to the square root of [the resistance squared plus (the difference of the inductive reactance and the capacitive reactance squared)]. The use of an alternating-current test set on a circuit containing capacitive reactance or inductive reactance would require some information concerning the relative magnitude of the quantities involved. This information is usually not available and for this reason the use of the magneto test set is rather limited in its application.

Practically all electrical machinery has a considerable amount of inductance or inductive reactance. The inductance of a circuit is directly proportional to the magnetic flux, the number of turns, and inversely proportional to the current. From the above it is seen that a large number of turns or an iron core will greatly increase the inductance of the circuit.

A shunt field coil has a very large number of turns and also has an iron core, and consequently has a large amount of inductance. The inductive reactance is directly proportional to the inductance. If the capacitive reactance is zero and the ohmic resistance is small in comparison to the inductive reactance, the impedance will be largely determined by the inductive reactance. All magneto test sets are rated to ring through resistance and not through impedance. In the above case the impedance is very large and the resistance is small; hence the magneto will indicate an open circuit because of its inability to ring through the high impedance of the field coil.

To test shunt field coils, when the magneto indicates an open circuit, direct current must be used. Several dry cells connected in series will in most cases give good results.

When the magneto indicates a ground or a short-circuit when none exists, it is caused by the capacitive reactance of the apparatus. The capacitive reactance is inversely proportional to the frequency and to the capacitance. The capacitance of a condenser is the measure of this condenser to hold a charge. Two conductors separated by a dielectric form a condenser. From this it is seen that all electrical apparatus must be composed of a large number of condensers.

Alternating current will flow through a condenser and as the magneto generates an alternating current and if the apparatus has sufficient capacitance, the magneto will indicate a ground or a short-circuit where none exists. Therefore, it will be necessary to apply some other test. As a rule electrical machinery does not have sufficient capacitance to cause the magneto to indicate a ground, this being more noticeable on transmission lines.

For insulation testing the Megger manufactured by the James G. Biddle Company, Philadelphia, gives excellent results. For information concerning its operation and construction, refer to literature of that company. It may be of interest to note that the Megger has a direct-current generator and for that reason it may be used where magneto test sets would give misleading results.

CHAS. F. CAMERON.
Rock Springs, Wyo.

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In reply to M. P.'s question, I would say that I have used the ordinary magneto testing set successfully for several years on general troubleshooting. It is a fact, however, that the high-resistance magneto will ring apparent grounds when they do not exist. But if one is careful in testing and turns the magneto handle himself he will find that the handle turns easily when the ground is "false." When the ground is "dead" or positive, the handle of the magneto will be found to turn hard; that is, it will be harder to turn than in the case of a "false" ground. The "false" ground also rings the bell with a fainter tone. If the magneto has about a 16,000-ohm rating it will be found to give better results for general testing of circuits and equipment. A 35,000-ohm magneto is not very well suited for ordinary work, but can be used to better advantage on high-voltage equipment, such as 6,000 volts and higher.

A very good ground testing outfit can be made by using an ordinary potential transformer such as used for voltmeters and other switchboard instruments. The usual tests are for 2,200 volts and below; so a transformer of 2,200/110 volts rating can be used. The low-tension side of the transformer may be connected to any 110-volt circuit through a fuse, while one side of the high-tension winding is connected to the machine or circuit to be tested, the other wire being connected to ground. If the machine or circuit is defective the primary fuse will blow. This is a fairly reliable test even on 2,200-volt equipment of small capacity. For finding grounds on stators and like equipment (provided no other method is handy) the normal voltage of the machine can be applied to one wire through a fuse and the oil switch thrown in; an arc is usually visible at the grounded coil.

On 500-volt shunt fields and some designs of 250-volt fields, the magneto gives a faulty indication; that is the bell does not ring, thereby indicating an open-circuit. Try breaking the magneto circuit while ringing; a small spark is usually visible if the circuit is not open. A magneto of 50,000 ohms will usually ring on these fields. If the voltage on which the fields operate is available they can be momentarily connected directly across the line. If the field has a magnetic pull or gives an arc upon breaking the circuit, the field is not open.

A magneto test is not infallible, however, as I well remember after intermittently testing a shunt field on a small motor for three or four hours. A circuit was indicated each time, but the motor operated as if it had an open field. Finally I pulled the lead wires to each field and found one of them to be loose.

GRADY H. EMERSON.
Birmingham, Ala.

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The reason that M. P.'s magneto indicated that a good machine was grounded, is because the machine had a small amount of electrostatic capacity between the conductors and ground. The magneto generates alternating current which, when impressed on even a small amount of electrostatic capacity, delivers a sufficient amount of current in charging the "condenser" to ring the magneto bell. Almost any motor, generator, rotary converter or power cable has some electrostatic capacity and, therefore, the magneto is of relatively little value for making tests on them.

As to why the magneto did not ring through the field coil—this is a case of inductance, which may be considered as the opposite of electrostatic capacity. The inductance acts as a "choke" to the alternating current from the magneto, to such an extent that the current which does pass through the coil is too small in amount to ring the bell.

This inductance phenomenon also makes it very difficult to use a magneto with any degree of reliability for testing insulation of field coils. For example, if the coil is grounded near one end of its winding, and the magneto is connected to the other end, the inductance through which the magneto current will have to pass before completing its circuit, may be so great as to prevent the bell from ringing. Or, if the ground is at the center of the winding, a test either way may still show clear on account of the inductance of the coil.

It is the writer's experience that the so-called magneto is of little or no value either for testing grounds or for test-

ing field coils. It rings through electrostatic capacity and does not ring through inductance. Also, a magneto gives no accurate idea as to the insulation resistance value in ohms, of the apparatus tested. On this point, when a test of insulation is made and the bell does not ring, one knows only that the insulation resistance is greater than a certain amount, this being the resistance rating of the magneto. Practically the only good use for a magneto is in testing the continuity of wiring.

The best way to test field coils is to connect them in series with 110 or 220 volts d.c. through a suitable lamp bank if necessary. Then, with a voltmeter, measure the drop across each coil. This test shows whether the windings are continuous, and also tells by comparison whether the coils have approximately the same number of turns. If the coils are known definitely to have the same number of turns of the same kind of wire, a variation in the voltmeter readings indicates short-circuited turns in the low-reading coils.

For testing insulation resistance an insulation resistance measuring instrument, such as a Megger testing set will be found useful. The Megger is a direct-current generator outfit, and has a direct-reading ohmmeter scale on which may be read the actual value of the insulation resistance. A recent modification of the Megger, known as the Meg Insulation Tester, generates 500 volts direct current and the scale reads up to 100 megohms (100,000,000 ohms), the first mark above zero on the scale being 10,000 ohms. Small amounts of electrostatic capacity do not affect the reading of this instrument. Neither is it affected by the speed at which the crank is being turned by the operator.

For large machines with a considerable amount of electrostatic capacity, use may be made of the Super-Meg, which generates a constant voltage by means of a slip-clutch arrangement when the crank is turned above its rated speed. Instructions for using these instruments are contained in our pocket manual 1060E. I shall be glad to send a copy of this manual to M. P. or to any reader who is interested in insulation resistance measurements.

James G. Biddle, Philadelphia, Pa. T. B. WHITSON.

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Replying to the question by M. P., the use of a magneto in testing is very likely to give misleading results, except in such work as is within the range of the instrument. A magneto is, in general, designed to ring through 20,000 to 40,000 ohms resistance. Electrostatic capacity must be considered when using the magneto in testing long circuits or cable circuits as it is this capacity that will cause the bell to ring and indicate a short-circuit, whereas no short-circuit may exist in this case.

Iron in a circuit has quite the opposite effect, but this is due to the inductance of the circuit which tends to prevent current from flowing, indicating an open circuit, and must be considered when ringing out the field coils of generators, motors and the like. Test bells and test lights are useful in many instances and also there are different devices on the market which are used as fuse testers to simplify testing work on electrical circuits. A telephone receiver may be wired as a circuit tester and is often used in this respect. The A. V. O. tester has a number of qualities to recommend it to the average electrician who does not have the money to spend for various instruments, as it is a combination voltmeter, ammeter and ohmmeter.

West Allis, Wis. EDWARD JAMES.

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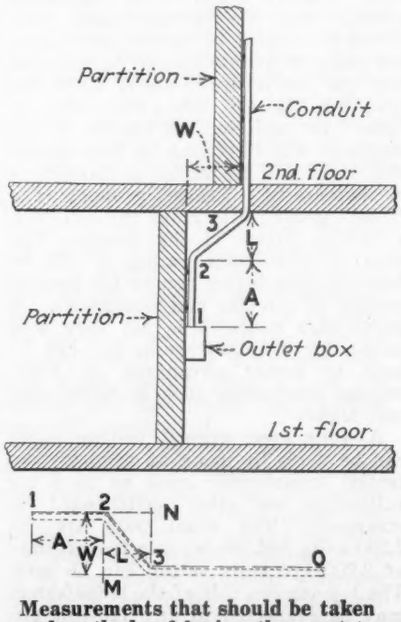
Measurements Required for Bending Conduit.—When bending conduit by use of a hickey, what measurements should be taken for making an offset, so that I can bend several conduits and have them match when placed side by side? I find it hard to get both sides the same on a double offset. Can some reader tell me how I can make a good-looking job by the use of a hickey on this kind of bending? If any readers have other devices or methods for making double bends and offsets I should like very much to know about them.

Worcester, Mass. R. S. T.

In answer to the question asked by R. S. T. regarding a method for accurately measuring an offset that is to be made in a conduit, I have used the following method with very satisfactory results.

For example, assume that a conduit is to be installed as shown in the accompanying illustration. It is to be run from an outlet box on the wall of the first floor, as at point *1*, up to the wall to the offset and then run up through the second floor and extend upward along the partition on this floor, as is shown in the diagram. To make an offset in a conduit so as to fit this location accurately, the procedure is as follows: First, measure the distances *A* and *L* between the points *1* and *2*, and *2* and *3*, respectively. Make the distance *L* as short as possible. Then measure the distance *W* between the wall on the first floor and the wall on the second floor; this is, in reality, the distance offset by the two walls.



Measurements that should be taken and methods of laying them out to insure making accurate offsets in conduits.

Then upon the floor or any flat surface that is convenient, lay off these distances as measured. In the bottom diagram these distances are laid off, the distance *A* being laid off as a straight line between points *1* and *2*, the distance *W* being laid off at right-angles to *A* between the points *2* and *M*; the distance *L* is laid off on an extension of the lines *1-2* between the points *2* and *N*. The line *N-3* is drawn in perpendicular to the line *1-2-N*; likewise line *M-3* is drawn in perpendicular to the line *2-M* to form the rectangle, *2-N-3-M*, as is shown in the diagram. The line *M-3* is then extended to the right, as is also shown in the diagram.

The diagonal to this rectangle is now drawn as shown at *2-3*. Conduit must then start at point *1* and follow along the line *1-2* until it reaches point *2*; it is then bent down to follow along the line *2-3* until it reaches point *3*, where it is then bent up or offset to follow an extension of the line *M-3* which is parallel to the line *1-2*. In other words, the line *1-2* represents the partition on the first floor and the line *3-O* represents the partition on the second floor. The line *N-3* represents the ceiling of the first floor, while point *2* is the point at which the offset or first bend is started. From this diagram the total length of conduit required can be measured directly according to the dimensions obtained.

In making the offset in the conduit, first place one end of the conduit at point *1* and at point *2* mark the conduit for making a bend. After making a bend by means of a hickey at point *2* until the conduit has been bent so as to coincide with the line *2-3*, point *3* can be marked on the conduit for the second bend. Then with the hickey at point *3*, bend the conduit upward until it coincides with the line *3-O* as shown in the diagram.

This is an exceedingly simple method of measuring and making an offset so that it will fit on the first trial and thereby eliminate unnecessary climbing of ladders and waste of time in trying and fitting, as prevails under the bend-and-try method and which also makes it difficult to do a good job.

By measuring the distance *A* one can avoid the necessity of cutting a short piece of conduit to piece out to the required distance. Special pains should be taken in measuring the distance *W* to insure that the exact distance is obtained between the two walls against which the conduit is to lay. The accuracy of this measurement makes all of the difference between a neat-appearing and a poor installation.

Plant Electrician, Freiberg Mahogany Co., New Orleans, La. OVIDE C. HARRIS.

* * * *

Replying to the question asked by R. S. T., I wish to submit the following data which I clipped from *Popular Mechanics* some time ago. I have used these data and find that with a little practice one can make right-angle bends in ½- and ¾-in. conduit quite accurately. With the larger sizes of conduit, it is necessary to use a bending machine. I use either a Lakin (made by Thomas & Betts Co., New

Data for Laying 90-deg. Bends in Conduit

Size of Conduit In.	Outside Diam. of Conduit In.	Standard Radius of Bend In.	A (—) In.	C (+) In.
½	⅞	4½	5	2
¾	1 1/16	5⅜	6	2½
1	1 5/16	5¾	6½	2½
1¼	1⅝	7¼	8	3¼
1½	1⅞	8½	9½	3¾
2	2⅜	9½	10½	4¼
2½	2⅞	10½	12	4½
3	3½	13	14¾	5¾
3½	4	15	17	6½
4	4½	16	18¼	6¾

York, N. Y.) or an Austin hickey (manufactured by M. B. Austin & Co., Chicago, Ill.) Either of these devices will give very satisfactory service.

The data for measuring a conduit for the bends are given in the accompanying table. An example of the use of this table is shown in the accompanying illustration. Suppose that a ½-in. conduit is to be run from the ceiling outlet box shown in the top illustration across the ceiling and down the wall.

Take a length of ½-in. conduit and lay out the distance *L* as shown in the bottom illustration. Locate in the first column, "Size of Conduit," the size of conduit you are working on—in this case, ½-in. On this line, you will find 5, under column "A—In," and 2 under column "C+In."

Then from point *B* on the conduit in the bottom illustration lay off 5 in. to the left as shown at *A*. Also lay off 2 in. to the right, as shown at *C*. Then start the bend at *A* and finish it at *C*. If the measurement *L*, in the top illustration is made to the conduit, instead of the wall, as is shown in the illustration, the diameter of the conduit must be added to the distance used as *L* in the bottom illustration.

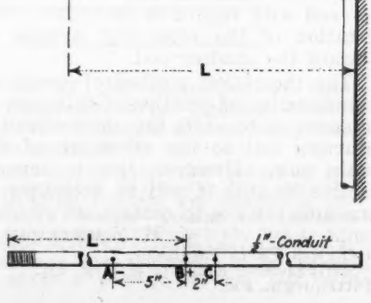
I use a 3-ft. piece of 1-in. conduit to slip over ½-in. conduit, and a 1¼-in. pipe to slip over ¾-in. conduit.

GEORGE W. STIRTON.

San Bernardino, Calif.

Method of measuring conduit for making bends.

By means of the table, the points *A* and *C* are located with reference to *B* which is placed a distance of *L* from the end of the conduit. The bend is started at *A* and finished at the point *C*.



* * * *

Low-Voltage Generator Will Not Excite.—It was necessary to rewind the shunt field coils of a 50-volt generator of very low capacity, which is direct-connected to a small motor having a speed of about 4,000 r.p.m. It is a two-pole machine having 2,000 turns of No. 37 wire in each shunt field coil. When the winding was completed, the machine generated 55 volts satisfactorily. It was then found necessary to reverse the generator position with regard to the motor, which of necessity reversed the direction of rotation; due to this reversal of rotation the residual magnetism of the generator was lost. When I separately excite the shunt fields from a 50-volt, direct-current bus the generator develops its proper voltage. When I reconnect the fields to the armature terminals I get a reading of only 1 volt. I wish some reader would tell me what is wrong and how I can correct this trouble.

Stamford, Conn. W. E. H.

In answer to W. E. H., it would appear that he is magnetizing the shunt fields for one polarity with the separate excitation and reconnecting the fields to the wrong armature terminals, so that the armature current bucks the residual magnetism that has been just built up.

To correct this either (1) connect the fields as formerly to the separate excitation, but reconnect them to the oposite armature terminals after separately exciting them, or (2) connect the fields to opposite terminals of the separate excitation and make the same reconnection of field leads to the armature as was formerly used.

CECIL W. ZIMMERER.

New York, N. Y.

* * * *

In answer to the question that was asked by W. E. H., I presume that his generator is a shunt-wound machine. When he changed the rotation of the generator mechanically he should have changed it electrically, and this is done by interchanging the shunt field leads at the armature. The very fact that it generated when first started and failed when he changed the direction of rotation, is sufficient evidence that there is nothing seriously wrong with the generator and his only trouble is that the reversed polarity of the armature (due to reversed rotation) tends to send current through the shunt fields in the oposite direction to that formerly obtained, with the result that the residual magnetism in the field poles is killed and the generator does not build up. WM. P. AMANNS.

Chief Electrician,
Knoxville Iron Co.,
Knoxville, Tenn.

* * * *

Answering W. E. H., the general description of the difficulty does not make any reference to the position of the brushes or the operation of the generator as to sparking at the commutator. While the flow of current in the field of a shunt generator is the same when operated as a motor or generator provided it revolves in the same direction as before a reversal of rotation, as outlined in the question, will cause a reversal in the generated voltage; hence the flow of current in the field winding will be reversed and the electromagnetism set up in the field core will oppose the residual magnetism so that the resultant magnetism for a self-excited machine will be practically zero. Hence, no voltage will be delivered by the machine when self-excited, unless some means such as separate excitation is used to give the residual magnetism the correct polarity, or by reversing the field connections, which will also give the same effect.

It will also be necessary for satisfactory operation to shift the brushes, in the direction of rotation, to a point where satisfactory commutation is obtained; that is, the electrical neutral point shifts ahead with a change of rotation, to a point which has the same angular relation with the mechanical neutral as before.

It is assumed in the foregoing discussion that the generator is of the non-commutating pole type.

C. OTTO VON DANNENBERG.

Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

In answer to W. E. H., I will say that it is necessary, if the generator is a shunt machine, to interchange the leads of either the armature or the field to cure his trouble. If the machine is a compound-wound generator W. E. H. should also reverse his series-field leads, should he decide to reverse the shunt-field leads. If the generator has an interpole winding and he should decide to interchange the armature leads he must also reverse the interpole leads or what is the same thing, but probably more convenient, the interpoles and armature connections can be reversed as a unit.

It may be necessary to separately excite the shunt-field winding in order to restore the residual magnetism in the right direction.

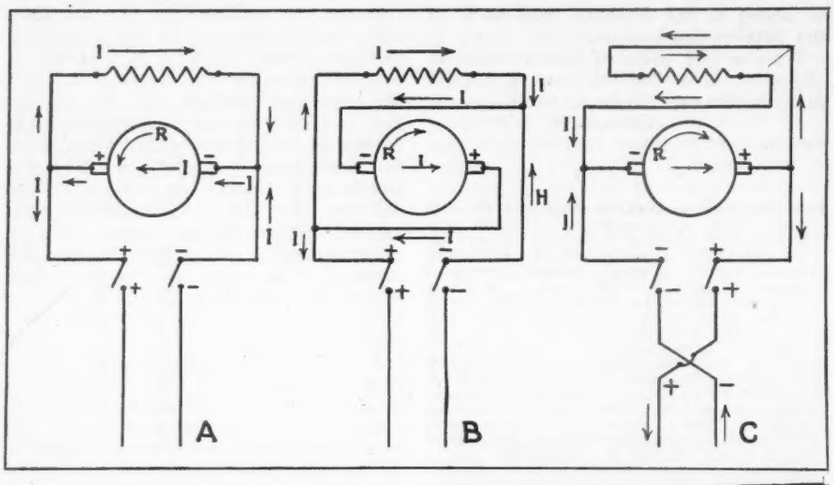
Ft. Dodge, Ia. CLAUDE D. MARTIN.

* * * *

In answer to W. E. H.'s question regarding the low-voltage generator that will not excite itself, the fact that, after he rewound the shunt fields, the machine generated 55 volts satisfactorily proves that his rewinding is correct. The direction of rotation of the generator was then reversed and the machine would not generate.

To correct the trouble, simply change the polarity of the field connections with regard to the armature. In other words, reverse the field connections to the armature or brush holders. This machine should now generate the same voltage as before, providing the speed is the same. On account of the reversed polarity which might have been set up in the field cores previously, it may be necessary to excite the fields once, from the bus or a battery, so as to obtain a residual magnetism of the correct polarity to start the machine generating.

This is exactly the same proposition as reversing the direction of rotation of a d. c. motor. If the generator has



Relation of direction of rotation, armature polarity, and field polarity, in motors and generators.

At *A* is shown the relation of field current, *I*, armature current, *I*, armature polarity, and direction of rotation *R*, for a generator. To maintain the same status after reversing the direction of rotation of the armature, it is necessary to reverse the armature leads as shown at *B*. This change could also be made by reversing the field connections, as is shown at *C*.

to run in the opposite direction of rotation the connections between field and armature must be reversed.

GUY H. WINTERSTEEN.
Cleveland, Ohio.

* * * *

In answer to W. E. H.'s question, I would say that on any direct-current machine there are four conditions which can be changed. These conditions are (1) change from a generator to a motor, or vice versa; (2) change in direction of rotation; (3) change in armature polarity; (4) change in field polarity. If any one of the above conditions is changed, one of the three remaining conditions must also be changed in order to bring the machine back to the same status as it was originally.

In the case mentioned by W. E. H., the direction of rotation was changed. The natural thing to change with the direction of rotation was the flow of current through the armature. When the voltage started to build up, current began to flow through the field coils in the opposite direction to its flow before the change was made. This produced a magnetic flux in the field which was in the opposite direction to the residual magnetism in the field poles, thereby cancelling the same, and preventing generator from generating.

If the armature terminals that were connected to the brush holders had been reversed, the voltage would have built up without any difficulty, for in this case the direction of current through the field coils would not have been reversed to that formerly obtained and consequently, the residual magnetism in the field poles would not have been killed. This can be done as shown at *A* and *B* in the accompanying illustration.

Sometimes, it is not convenient or permissible to interchange the armature leads on the brush holders. In such cases the change can be made by reversing the connection of the shunt-field coil to the busbar leads, as is shown in *C* of the accompanying illustration.

Probably the easiest way of correcting the trouble that W. E. H. is experiencing, would be to change the direction of rotation of the generator by reversing the direction of rotation of the motor, thereby bringing the generator back to its original operating condition.

J. M. ZIMMERMAN.
Renewal Parts Engineer,
Westinghouse Elec. & Mfg. Co.,
Pittsburgh, Pa.

* * * *

Effect of Turning Rotor on Split-Phase Motors—I recently had to make repairs on some split-phase motors, and found it necessary to turn down the squirrel-cage rotors. I wish some reader would tell me what effect this would have on the motor characteristics, such as speed and capacity? Also, can some reader tell me how to reverse the direction of rotation on shaded-pole type motors? What is the rule for determining the direction of rotation on such motors?

Hood River, Ore. V. G. W.

Replying to question by V. G. W. about turning down the rotor of a split-phase motor, the actual effect would be to increase the magnetizing current because of the larger air gap. This increase would probably be noticed most at no-load operation. Such a condition may be compared to a transformer with loose joints in the air gap.

C. OTTO VON DANNENBERG.
Designing Engineer,
Sanderson & Porter,
Springdale, Pa.

* * * *

In answer to V. G. W.'s questions, I will consider each one in the order asked. The first and most important effect of reducing the diameter of the rotor is to enlarge the air gap, which increases the magnetizing current and decreases the power factor. Stray or leakage flux is also increased affecting the pull-out torque and tending to make the motor noisy in operation.

The net effect of reducing the diameter of the rotor is to decrease the full-load rating or increase the operating temperature, depending upon the total per cent change of flux density in the air-gap. Enlarging the air-gap 0.003 in. may cause an increase in no-load current of 5 to 10 per cent. It is hard to lay down any other rule than to advise against turning down the rotor any more than is absolutely necessary.

The only method of reversing the direction of rotation of shaded-type pole windings, is to turn the winding unit over end for end; that is, if both end bells are interchangeable, remove them and turn the rotor and stator around 180 deg. The direction of rotation will be towards the shading coil.

Wilkinsburg, Pa. A. C. ROE.

* * * *

In answer to the inquiry by V. G. W., turning down a squirrel-cage rotor will have a tendency to cause the motor to use a higher magnetizing current, which will lower the power factor, with a corresponding decrease in output. The starting qualities will be somewhat poorer and the pull-out point higher in proportion with a correspondingly lower speed.

The direction of rotation of shaded-pole motors is opposite to the end of the pole on which the shading coil is placed; that is, the shading coil is on the leading end of the pole. In changing the direction of rotation the shading coil is moved to the other half of the pole tip and automatically becomes the leading edge by virtue of the new direction of rotation. When changing the position of the shading coil too deep a cut will destroy all good characteristics of the motor, but a light cut will not effect the starting and stalling characteristics.

Newark, N. J. EDWARD JAMES.

* * * *

In answer to V. G. W.'s question, turning down the rotor of a split-phase motor increases the air gap, leakage flux, and magnetizing current, which in turn decreases the efficiency of the motor. However, this decrease will be small, depending upon the increase in length of the air gap. The slippage of the motor will be materially increased and the motor will accordingly run slower at full load. It will also pull out of step at a lower load than that for which it was originally designed. Unless this motor is overloaded, no appreciable difference should be experienced in its operation, if the double air gap is not increased more than 0.055 in.

The easiest method of reversing a shaded-pole motor is to remove the end bracket and turn the stator end for end, relative to the rotor. Sometimes it is more convenient to press the laminated core out of the frame with the field coils attached and turn it end for end with regard to the rotor. The rotation of the rotor will always be toward the shading coil.

The theoretical method of reversing the direction of rotation of this type of a motor is to shift the short-circuited starting coil to the other tip of the main pole. However, this is impracticable because it will be necessary to machine the slot to contain the shading coil.

J. M. ZIMMERMAN.
Renewal Parts Engineer,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Pa.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Improved Method of Connecting Auto-Transformers For Lighting Circuits

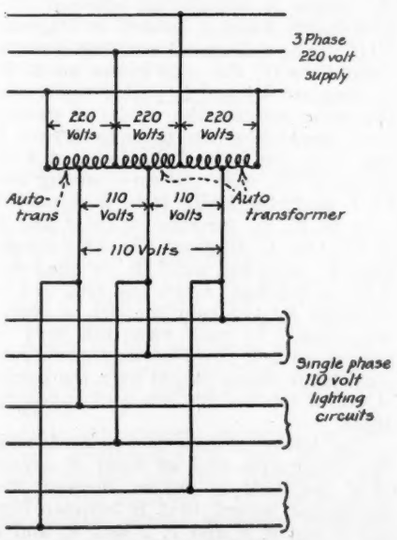
IN A GREAT many industrial plants the power supply is three phase, 220 or 440 volts, and the lighting supply is obtained from these power circuits by means of transformers connected thereto. It is quite common practice to connect an auto-transformer across one phase of the three-phase supply, the auto-transformer having a mid-tap, so that a 220/110-volt three-wire, single-phase supply is obtained. This system has several disadvantages, the more important of which are as follows: As all of the lights are connected to only one of the three phases, the lighting load unbalances the power circuit to a certain extent. A ground on the neutral wire in a three-wire lighting circuit is likely to disturb the equality of voltages in the three-wire circuit and may place as high as 220 volts across the 110-volt lamps.

In the connection scheme shown in the accompanying diagram, three auto-transformers are connected in delta across the three-phase power supply. Now, instead of using the line wires through the auto-transformer as well as the mid-taps, only the mid-taps are used to supply the 110-volt lighting circuit. The voltage between any pair of mid-taps is equal to the vectorial sum of half the voltage in the two auto-transformers to which the mid-taps connect. In other words, the resulting voltage equals $2 \times 110 \times 0.5 = 110$ volts. This is due to the fact that the two voltages are 120 deg. out of phase, thereby resulting in a voltage of only 110 volts.

With this connection scheme, three 110-volt, single-phase lighting circuits are obtained, which are 120 deg. apart in phase relation. By balancing the lighting load equally across these three single-phase circuits a good balanced load condition will be obtained.

An advantage of this connection scheme lies in the fact that grounds will not disturb the voltage on the different circuits and it is impossible to obtain overvoltage, thereby burning out lamps. However, it should be remembered that with this connection of auto-transformers it is quite easy to overload them, for in the more usual connection with a balanced load between the two outside wires of the three-wire circuit, the transformer is required to carry very little load, as practically no current flows through the neutral wire. With the connection scheme just described the total lighting load passes through the auto-transformers and due consideration should be given this fact when deciding upon the size of auto-transformers. However, I think that the elimination of overvoltage due to grounds will overbalance this disadvantage.

WM. P. AMANNS.
Chief Electrician,
Knoxville Iron Co.,
Knoxville, Tenn.



Use of this connection of auto-transformers on lighting circuits prevents danger of overvoltage due to grounds.

As may be seen, the feature of the connection lies in the fact that the lighting circuits are connected between middle points of adjacent auto-transformers which, due to the fact that the voltages in each transformer are 120-deg. out of phase, gives a voltage of only 110 volts.

Method of Using Flashlight For Testing Fuses

THE present-day, fused safety switch has a separate compartment for the fuses, the door of which cannot be opened until the safety switch is open. This is done for safety reasons, so as to prevent any one from changing or inspecting the fuses while they are alive. However, it prevents testing the fuses in the usual manner by shunting a test lamp across a pair of fuses while they are "hot."

To test the fuses that are used in a safety switch of this kind, it is necessary to remove them from the fuse blocks and test them with a magneto, or by connecting them through a test lamp with a source of power. At our plant we have devised a method of testing these fuses which is much more convenient and fully as reliable as the two methods just mentioned.

All of our motor inspectors carry small flashlights that have fiber cases. We have soldered a strip to the top connection of the switch on the side of the flashlight case; the other end of the strip is soldered to the metal band on the fiber case that screws into the cap, which holds the lens and the reflector. With this arrangement we are able to test a fuse by shorting it across the metal bands or ferrules at the top and bottom of the flashlight.

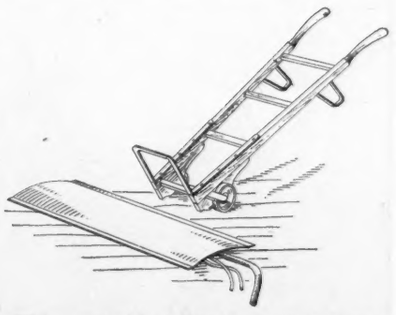
On some types of flashlights having fiber cases, the top and bottom caps or ferrules form part of the electric circuit that lights the bulbs. In such cases, if the flashlight should be laid down on a metal sheet, the light will burn even though the switch is off. With this type of flashlight the fuse may be shunted directly across the top and bottom ferrules and if the fuse is not burned out the flashlight will burn.

Chief Electrician, Shevlin-Hixon Co., Bend, Ore. WM. B. CONE.

Protecting Wire or Hose Lines Lying on Floor

IN THE use of portable electric or air tools it is often necessary to carry the lines across an aisle or other space where men are working or where trucking is necessary. Neither hose lines nor power wires will stand being trucked over without being damaged.

One method of protecting these wires is by the use of a special portable bridge, such as is shown in the accompanying illustration. This is made of sheet metal which may be of any thickness sufficient to stand the heavy or light traffic in the plant. A slight curve is made in this bridge to raise the center high enough so that air hose



This portable sheet metal bridge protects the electric power or hose lines for portable tools where they cross a passageway or aisle.

can lie underneath it without touching. The edges are bent so that they lie flat on the floor and also are beveled so as not to give an abrupt obstruction to the wheels of the truck. This bridge was made and is kept by the maintenance department and taken to any job where the men in this department find it necessary to use it.

Laying Conduit for Difficult Underground Installation

WHILE installing six white-way lamp posts recently near the entrance of a building, a local contractor had to overcome a very difficult problem of laying underground conduit. Two of the lamps were installed at the entrance of this building where a sidewalk 25 ft. wide was located and the other four lamps were placed equidistant along a 6-ft. walk leading up to the entrance.

In order to wire these lights, it was necessary either to cut through the concrete sidewalk or go under it. If the walk were cut through an ugly patch would be the result, along with the extra work and cost of making and repairing the break. The conduit required was ¾ in.; so it was decided to drive the pipe under the walk to eliminate digging a trench.

An iron spearhead 8 in. long and conical in shape, having a ¾-in. base which was threaded to fit into a ¾-in. sleeve, was made for this purpose. The sleeve and spearhead were then screwed into the length of conduit and driven with a hammer to where the earth was dug out to locate the concrete foundation for the post. The pipe was sawed off to the correct length after being driven through, and threaded with a ratchet die. This cutting operation also removed the battered end in each case without extra work. The spearhead fitting was reused in a similar manner to place the conduit required for each lamp. One length of conduit was lost in forcing it under the 25-ft. sidewalk and another was deflected by an obstruction, probably a rock. This length of conduit had to be removed with rope pulley blocks and a new location was tried with success.

In soft earth a pipe cap could probably be used to protect the threads on the driven end.

Heavy pipe a size larger than the conduit to be used, might be flattened on one end and used to make an opening in the ground. It could be cut off after being driven through and the conduit inserted which would make the process more costly, but more sure. This method would also be adaptable for installing steam or water pipes.

GRADY H. EMERSON.

Birmingham, Ala.

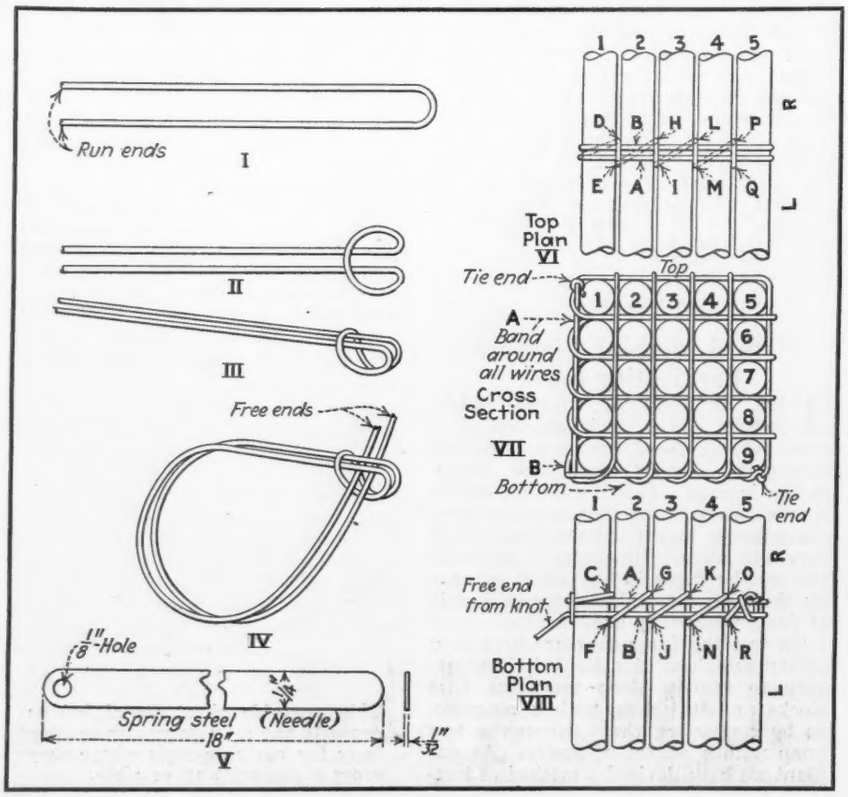
A Handy Stitch For Use When Tying Small Cables

WHEN wiring up switchboards and mounting resistance grids or controllers and so on, there are in most cases a number of small cables to be run and kept together in a neat and workmanlike shape. There is a stitch known as the "Chicago" which is used in running cables in telephone exchanges and keeps the cables square and neat in appearance, regardless of the number in the group. This Chicago stitch may be used to attach a group of cables firmly to an iron support, or used as a means to keep them lined up properly. When this stitch or tie is completed the cables can be hit with a sledge-hammer without knocking them out of line.

The first step in making this stitch is to cut a single length of cord long enough to pass around the cable group enough times to equal the number of cables wide multiplied by the number deep times two. For example in diagram *VII* of the illustration the cord is long enough to pass around the cable group 5×5×2=50 times, or the length of one turn multiplied by 50 is required. This single cord is doubled in half as shown in diagram *I* and folded back on itself, diagram *II*, forming an open loop on each side of the running ends. These two loops are then bent down on each side of the running ends as in diagram *III*. The next step is to hold these loops in one hand and with the other hand pass the free or running ends around the group of cables, through the sliding loop, as in diagram *IV*. When these loops and ends are pulled tight, they square up the cables at the same time.

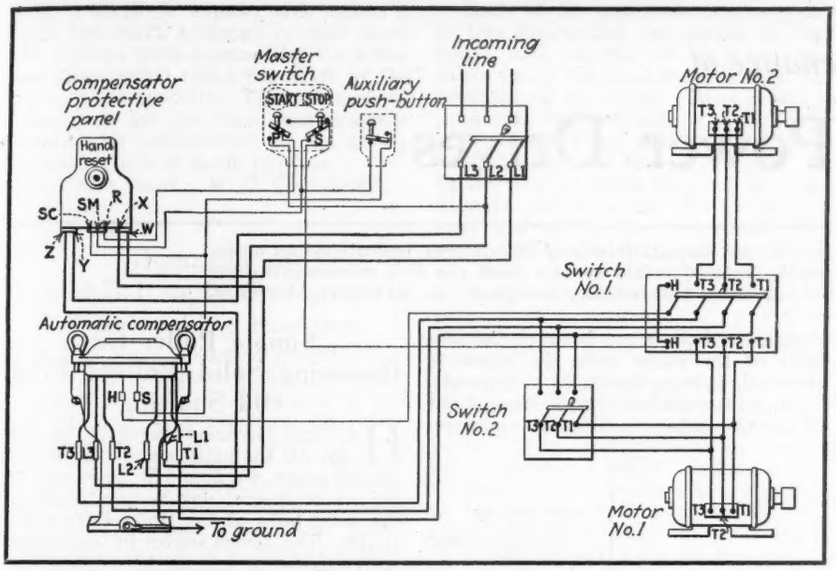
After tightening up the double cord band around all the cables there will be two long, free ends left hanging, one of which is shown in diagram *VIII*. The knot is made at the bottom to bring the free ends into a position to use. Selecting either free end of the cord to thread the steel needle shown in diagram *V*, the cord is brought up between the first and second vertical layers of cable on the right-hand side of band *A* at *C* in diagram *VIII*. (Note that left and right are indicated by *L* and *R* at the side of the diagram.) After pulling up all the slack and tightening the cord, the threaded needle is passed between layers *1* and *2* on the opposite or left-hand side of band *A*, or *D* to *E* in diagram *VI*. Crossing over to the right-hand side of band *A*, the needle is brought up between vertical layers *2* and *3*, as at *G* in diagram *VIII*. Thus a diagonal crossing is made from *F* to *G*; the cord comes up at *H* in diagram *VI* and is pulled tight. In the same manner the needle is passed over band *A*, down through layers *2* and *3* at the left of the band at *I* in diagram *VI*, with the cord coming out at *J*, diagram *VIII*. It is then passed over to *K*, up through layers *3* and *4* to position *L*, diagram *VI*. This operation is repeated until *R* in diagram *VIII* is reached, where the free end is fastened by the loop through a previous turn. In each case the cord is passed up and down between each vertical layer, being looped over the bands *A* and *B* top and bottom, and pulled up tight.

The above process is repeated with the other free end or band *B* except that the cord is passed through the horizontal layers, that is between layers *9* and *8*, *8* and *7*, *7* and *6*, and *6* and *5*. In making a study of diagrams *VI*, *VII*, and *VIII* it will be noticed that each cable is held with a double



Steps in tying cables with the Chicago stitch.

Diagrams *I*, *II* and *III* show how the cord is looped for sewing. The method of tying in the cables and the positions of the cords are illustrated in diagrams *VI*, *VII* and *VIII*.



Control connection scheme for using one compensator for starting two motors.

By means of transfer switch No. 1, the compensator may be connected to either motor for service duty. In case of fire when both motors must be operated at the same time switch No. 1 is thrown upward and switch No. 2 is closed.

cord band on all sides and so locked it is held solidly and firmly. If it is desired to attach the cables to an iron support the same method is used except that in the up and down or cross cable looping, the loop is made each time around the iron support. Suppose for example that the iron support was on the bottom in diagram *VIII;* when passing from position *F* to *G*, the loop would be made around the iron support. For light and springy cables the tie bands should be spaced 12 in. apart; for rigid wires such as solid, fireproof, or insulated, the bands should be spaced 18 in. apart.

This is a simple stitch to apply after the method of procedure has been acquired and will be found handy around power stations, industrial plants or in any place where a number of cables or wires are grouped and run for any distance.

Wilkinsburg, Pa. A. C. ROE.

Automatic Switching Simplifies Use of Pumps for Fire and Service Duty

WHEN water is needed to fight a fire, is no time to think of sparing the motors that drive the pumps. They must do their duty, even though they may be seriously overloaded. What is a motor or two compared to the thousands of dollars worth of equipment which will be endangered if they stop running?

With this thought in mind, the electrical department at the Newcastle plant of the National Radiator Company have installed a system whereby the service pumps have the combined duty of furnishing service water and fire protection. When these pumps are at work during a fire, nothing but a power failure or burned-out motor can stop them.

Two Deming triplex-pumps, each driven by a 15-hp. motor, alternate on the job of supplying high-pressure water for testing the castings for radiators and boilers. One of these pumps is sufficient for this service, so that the other serves as auxiliary equipment. An Electric Controller & Mfg. Co. 15-hp. automatic compensator, provided with a switch, is used to start either of these pumps by means of a push button. The operating motor is protected against overloads by a protective panel which opens the motor power supply circuit through the compensator.

The diagram shows the scheme of connections. When motor No. 1 is being operated for pumping water for test service, switch No. 1 is in the downward position and switch No. 2 is open. Motor No. 2 may be operated similarly by throwing switch No. 1 upward and leaving switch No. 2 open. Thus it is seen that switch No. 1 is simply a means of transferring from one motor to the other.

Twice a month, fire drills are held at this company's plant, and every man is trained to perform his duties in an efficient manner. At the pump station there is great activity when the fire whistle sounds, for one pump is in operation and may be supplying water for test work. So the first thing the man assigned to the pumps must do is to shut down the pump, close the valve leading to the test department, and open the one which parallels the two pumps on the fire system.

The problem is to start both pumps at once with two 15-hp. motors connected to a single 15-hp. compensator. It is quite evident that this is a decided overload; so the overload protective panel must be cut out before the starting button is pressed. This is done by an auxiliary push button which cuts out this panel and permits the motors to operate continuously at any overload. Normally, this push button is locked so that the protective panel cannot be cut out accidently. Switch No. 2 is closed and switch No. 1 is thrown upward for paralleling the two motors through the one compensator and when the start button is pressed, they are brought up to speed automatically. From that time on these pumps will continue to run until the stop button is pressed or until trouble causes the motors to fail.

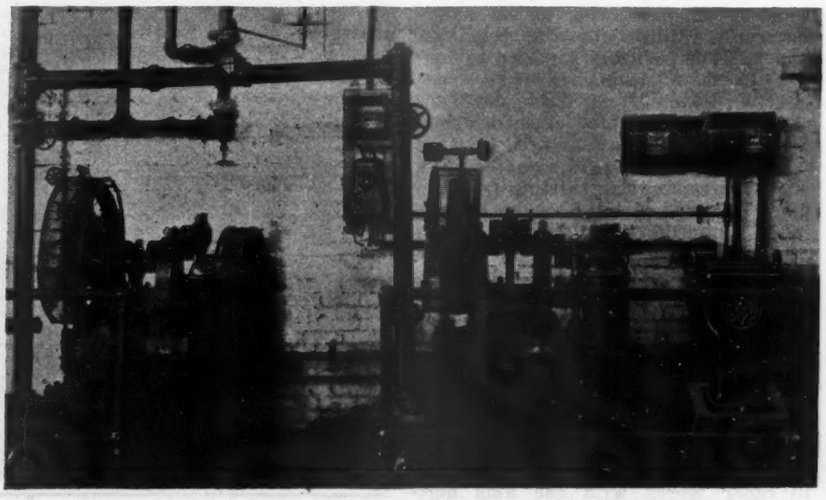
A feature of this switching arrangement is that it is entirely fool-proof. Should the operator fail in the confusion of a fire to shut down the pump on service duty before he attempts to parallel the two motors on the line, throwing of switch No. 1 to do this paralleling, automatically disconnects the motor which is operating on the line. Then when the start button is pressed the two pumps are brought up to speed at the same time through the use of the automatic compensator.

L. S. MONROE.

The Electric Controller & Mfg. Co., Cleveland, Ohio.

Only one compensator is required for starting the motors which operate the two pumps shown here.

Two 15-hp. motors connected to a single E. C. & M. 15-hp. automatic compensator are operated in parallel in case of fire to drive two Deming triplex pumps. Normally only one motor and pump are required to supply water for testing and other purposes.



Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Using Auto Tire Dust Caps as Oil Cups on Motors

OIL cups are an absolute necessity on a motor using the cup and wick oiling system. However, it is often rather difficult to replace these oil cups when they become lost, and suitable substitutes which may be obtained easily may come in very handy as it is not good practice to leave the oil hole open, particularly in dusty locations.

Dust caps from automobile tires make excellent oil cups and are of the proper size for most small motors and fans. If a thread-cutting lathe is not available, turn or file a slight taper at the open end of the cap, so that it can be started into the motor and saw a slot lengthwise through the tapered portion. If the cap is screwed up tightly it will stay in place and give good service.

Durant, Okla. J. P. KINCAID.

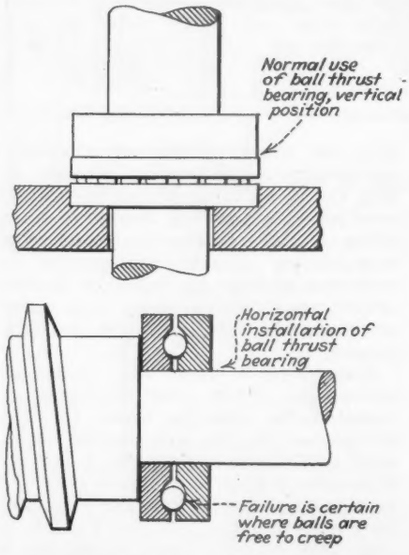
Improper Use of Thrust Ball Bearings on Worm Causes Trouble

THRUST ball bearings are not so commonly used as are radial ball bearings. Unless full consideration is given to the detail construction of the bearings and the manner of mounting, the bearing may fail apparently without cause. One such case was in connection with a ball thrust bearing on a worm drive. The worm was mounted horizontally with radial ball bearings and in addition thrust ball bearings were used at each end to take the worm thrust. Every few weeks, the thrust bearings would fracture or the balls would break. According to the manufacturer's ratings for the bearings, they were of sufficient capacity to sustain the thrust loads which were imposed on them.

After considerable experimenting, one of the engineers suggested that the balls in the bearing be mounted in a cage to prevent their shifting position. When this was done the bearing trouble ended immediately. Manufacturers generally recommend the use of a cage or retainers to space the balls properly and keep them in position. Many times, however, attempts are made to apply balls without such a retainer.

The explanation of this trouble described above is that a thrust bearing, when mounted with the ball race horizontal, will operate without any difficulty. When it is placed on edge, or in other words with the axis horizontal, the balls creep between the sections of the races when the screw is reversed, causing the races to separate. This causes the balls to be caught out of position when the load is again reversed and applied on the thrust bearing. The lowest ball then carries the major part of the load and either or both the ball and races fail. The use of a cage maintains the alignment of all the balls in their proper positions, distributes the load uniformly and so prevents further trouble from such sources.

Washington, D. C. G. A. LUERS.


Normal use of ball thrust bearing, vertical position
Horizontal installation of ball thrust bearing
Failure is certain where balls are free to creep

How the thrust load is applied on vertical and horizontal ball races. When a thrust ball bearing is used on a horizontal shaft the balls may be crushed, as shown in the lower drawing, unless a cage is used to retain the balls in their proper position. The conditions are different with vertical thrust and loads, as indicated in the upper drawing.

Simple Puller for Removing Solid Pulleys From Old Shafting

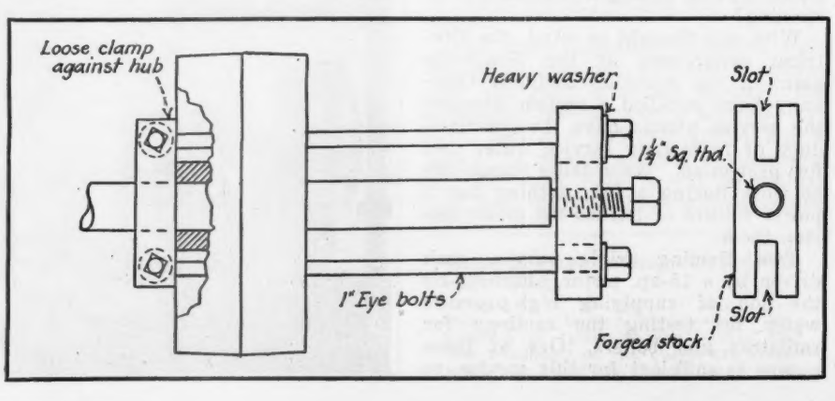
HAVING occasion recently to dismantle the pulleys and shafting in an old plant, we found it necessary to rig up a special device for loosening the solid hubs of the pulleys from the shafts. The device shown in the accompanying sketch was used.

This puller was to be used on shafts of different diameters; so the clamp which fits behind the pulley was made up of two ⅝-in. by 3-in. pieces of bar steel and bolted together so that the edges of the bars fitted against the hub of the pulley. Eyebolts were inserted as shown. These eyebolts were made of 1-in. round steel, 5 ft. long, and were threaded for about 4 ft. It happened that all of the pulleys were within 4 or 5 ft. from the end of the shaft. These eyebolts could have been made any length desired.

A piece of 3-in. by 4-in. forged steel stock about 6 in. long was slotted at the ends. A hole was drilled in the center of this and tapped for a 1¼-in. square screw thread and a bolt made to fit. This slotted bar is shown at the right in the sketch below.

The clamp was placed around the shaft back of a pulley hub and the nuts on the eyebolts placed in the slots with large washers under the nuts. The bolt with the square thread was then tightened against the end of the shaft.

Previous to doing this the shaft around the hub was well soaked with kerosene; then it was tapped with a hammer as the pulling force was applied with the screw. In some cases it was necessary to heat up the hub



Solid-hub pulleys were easily removed from shafts with this puller, when dismantling an old plant.

with a torch to expand and loosen it from the shaft, although in most cases the pulleys were loosened by the screw and then pulled along the shaft by the nuts on the eyebolts. This device more than paid for the time and material used in its construction by the saving in time which it made possible.

Hollywood, Calif. M. C. COCKSHOTT.

Discussion of Use of Belt or Chain Drives for Woodworking Machines

IN NO other industry, probably, are the advantages of the individual drive so generally recognized as in connection with woodworking. The product is so bulky that a re-arrangement of machines independent of lineshaft restrictions may represent such savings in materials handling costs, maintenance charges, floor space, and power costs that the cost of a new installation or of the rearrangement of an old one is completely wiped out in a few months.

The machine room in a steam-driven "planing mill" was a fearsome place; the whole building shook with the pulsations of the machines and shafting, and overhead hangers, shafts, and pulleys were deeply coated with oil and dust. Back of many machines about 10 ft. of space was railed off for the jackshaft serving that machine and from which several belts drove various heads and feeds. Contrast such conditions with that of the accompanying illustration, which is a good example of a modern mill that has kept the same machines but applied individual drives to them.

Each of the machines that appears in this illustration has gained in floor space and, instead of a large area taken up by the drive there is only that occupied by the motor. Also, power is used only when needed.

Whether to use belt or chain drive from the motor is often a problem. No better way to decide this can be found than to put in a few drives of each kind and watch the performance and costs through a period of years. If the chain is to be left exposed to woodworking conditions, it will not give more than a fraction of its normal years of service. A belt stands up better in the dust and chips, although these will dry out and crack any belt if it is continually neglected.

In the immediate foreground, a 1,500-r.p.m., 10-hp. motor is shown driving an American outside molder. This driving speed is reduced to 800 r.p.m. on the jackshaft through 25- and 47-tooth sprockets. The Morse chain is ½ in. pitch and 3 in. wide. One of the advantages of chain drive is that it permits the use of close centers. In this particular case, the shafts are 18 in. apart and could have been made closer if it had been necessary. It would not be practicable to run belts with such small pulleys, and larger pulleys would have been impossible on account of interference. So long as odd numbers of teeth are used in the sprockets to prevent links running in the same teeth all the time, there is no hard and fast restriction as to close centers, although it is well not to go closer than four times the diameter of the small sprocket.

A belt-driven saw, which is also shown in this illustration, is connected up to operate at double the speed of its 1,500-r.p.m. driving motor. In this case a 4-in. belt is used. An automatic idler insures the proper driving tension. The motor is mounted on a sliding base which is used to take up the belt stretch; the chain-driven motor also has a sliding base, although it might have been eliminated.

The saw was belt-driven because of the difficulty of covering the upper sprocket of a chain drive so that it would be protected from cuttings and also because it was not easy to remove the shrunk-on pulley from the arbor and put on a sprocket instead. The installation is an example of good practice.

Except in some unusual locations, the use of an idler is an admission of the inadequacy of the particular belt drive. In this case, as with most saws, the driven pulley is small and the idler does increase the arc of contact, besides adding to the tension of belt on the pulley. However, all these benefits are at the cost of increased bearing friction. If a belt drive will not pull the saw, the most logical plan is to increase the width of pulleys and belt; this can be done for a cost as low as that of the idler. On installations where the idler is used for taking up the stretch in a belt, instead of cutting and lacing or cementing, it functions as a take-up and its use is justifiable, in the writer's opinion.

For use on drives where a small diameter pulley or sprocket and close clearance are unavoidable, chains may prove the solution in spite of their apparent handicap. A belt is thin and it will wrap itself around a small pulley very easily. On the other hand, a chain of the proper pitch will also conform to small diameters and, as its driving ability does not depend upon friction, the small diameter may usually be decreased enough to permit the outside of the chain to come within the same clearance without any sacrifice of pulling power.

The writer has successfully used small sprockets on saws with small-diameter, high-speed shafts. Where a separate sprocket would be too large, new arbors have been used and the teeth cut integral on the new parts.

As shown in the illustration, a substantial cover has been built around the chain drive. This cover has a hinged top, which permits inspection and lubrication without requiring the use of any tools which might fall inside. Industrial men who have placed covers equally as good about their short-belt drives have also been amply repaid, as the life of belts which are well cared for is about as long as that of chains.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Because of the high speed at which woodworking machines operate the selection of the drive is of especial importance.

This illustration shows how a silent chain and a belt were used on different woodworking machine drives. In one case the speed is stepped down, and stepped up in the other. Additional interesting considerations concerning these drives are discussed in the accompanying item.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contribution are always welcome.

Proper Method of Cleaning Dirty Storage Battery Boxes

SOME very interesting information as to the proper method of cleaning storage battery boxes was given in a recent issue of *Pullman News*. It seems that the Pullman Company has discontinued the practice of cleaning batteries with water. It was found that the practice of washing out battery boxes at the time batteries are flushed or when an accumulation of foreign matter has collected, is responsible to a large extent for many leaky cells found in service. Such leaky cells are caused by the electrolytic action of the current flowing between adjacent cells or crates and woodwork of the box, to grounds caused by wet and acid-soaked crates and battery boxes.

A battery box should not be washed out except when it is especially dirty or acid-soaked, in which case it is advisable to neutralize the acid with a soda solution and then wash out with a flushing hose. It is impossible to wash acid out completely with plain water, particularly when the acid has penetrated the woodwork.

When neutralized by a soda solution as described above, all traces of acid are removed and the box will quickly dry after washing. Care should be taken when flushing to prevent cells from being over-flushed.

Simple Device for Rewinding Blowout Coil

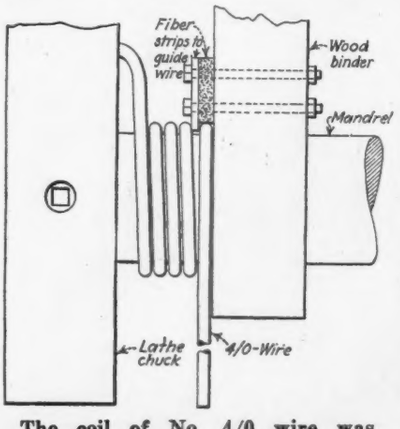
WHILE repairing a 200-amp. circuit breaker, it was discovered that a blowout coil had become crystallized in a flashover and was so brittle that it fell apart in dismantling the breaker. This breaker was of an old type and a new coil could not be obtained in less than 60 to 90 days. So ways and means of making another coils were considered in order to avoid this extra delay.

The coil consisted of 12 turns of ½-in. round, bare copper, with an inside diameter of 2¾ in. We found that a local supply house could furnish us with 9 ft. of the No. 4/0 wire which we required. No. 4/0 wire has a diameter of 0.46 in., which was close enough.

An old piece of shafting was placed in the lathe and turned down to 2¾ in. for a distance equal to one and one-half times the coil length. For this operation the tailstock of the lathe was run back and the shaft held in the chuck on the headstock. A block of maple was cut 2 in. by 6 in. by 18 in. and a 2¾-in. hole bored at one end of the maple block, so that it could be slipped over the shaft. A piece of ½-in. fiber was fastened by bolts to one side of this block ½ in. above the hole. A strip of ¼-in. fiber was then placed over the ½-in. fiber and allowed to project slightly, forming a groove for the turn being wound on, as shown in the illustration.

The wood binder or maple block was put on over the mandrel or shaft and one end of the copper wire was fastened to the chuck. A quarter of a turn was made with the wood binder; then the lathe was turned over a quarter of a turn and this was repeated until the 12 turns were wound. Holding the mandrel in the lathe chuck provided good control over the winding process and prevented backlash and loose turns, which would otherwise be a hindrance to winding.

The coil was insulated with one, half-lapped layer of treated cloth tape and one, half-lapped layer of 0.007-in. cotton tape and then dipped in liquid Bakelite and baked. The last two turns at each end of the coil were reinforced with an extra layer of cotton tape. When the tape was applied to the turns, the coil was sprung open and then pressed together before dipping.



The coil of No. 4/0 wire was formed around a mandrel by means of a maple block which was slipped over it.

Two pieces of fiber fastened to the side of the block form a projection with a groove which serves to bend and guide the wire.

Considering the crude tools used, the quality of the coil was good, combined with the features of neat appearance, quick delivery, and low cost.

Wilkinsburg, Pa. A. C. ROE.

Changing Speed and Horsepower of Induction Motors

IN MOST industrial plants, owing to the many changes in equipment, it is often found necessary to decrease or increase the horsepower of induction motors. The two instances cited below are typical problems of this character.

One case involved a 100-hp., 60-cycle, 1,200-r.p.m., 550-volt, three-phase induction motor direct-connected to a 10-in. centrifugal pump. This pump was taken out of service and a hydraulic pump for a different service was then installed, which required a 50-hp. motor operating at about 700 r.p.m. It was decided to change the speed of the 1,200-r.p.m., motor so that it could be used on the new pump.

The horsepower output of the motor at the changed speed was checked first since the horsepower increases or decreases in direct proportion and in the same direction as the speed, if the voltage also is changed. With a decrease in speed from 1,200 to 720 r.p.m., which is the nearest synchronous speed to 700 r.p.m., the motor would develop (100×720)÷1,200=60 hp.

As this horsepower was near enough to that required, more data were carefully obtained. The stator contained 72 slots and 72 coils; the pitch was 58 per cent of full pitch. The coil sides were placed in slots *1* and *8*, while full pitch would be, 72 (slots)÷6(poles)=12. The chord factor at full pitch, or 12, equals 100 per cent and is also the sin of one-half the angle covered by the coil throw. The span is 180 deg., which at full pitch is 180 deg.÷12=15 deg. per slot. The throw of 1-and-8 covers seven slots; 7×15=105 deg., and the sin of one-half of 105 deg. or 52.5 deg. equals 0.79 which is the chord factor of the winding. The original winding is shown in Fig. 1 *A*.

The next important item considered was the pitch with the changed connection. The motor was originally connected for six poles, or 1,200 r.p.m., while the new connection for 720 r.p.m. would be 7,200÷720=10 poles. Full pitch with ten poles equals 72(slots)÷10(poles)=7.2. Since the original winding pitch was 1-and-8, 7.2 was near enough to consider the changed winding as being full pitch or practically 100 per cent chord factor.

The motor was to be used on 550 volts, as before; so the effect of the change in speed would be to reduce the counter emf. from 550 to (720×550)÷1,200=330 volts. However, 550 volts was the original impressed voltage with a chord factor of 79 per cent, and since

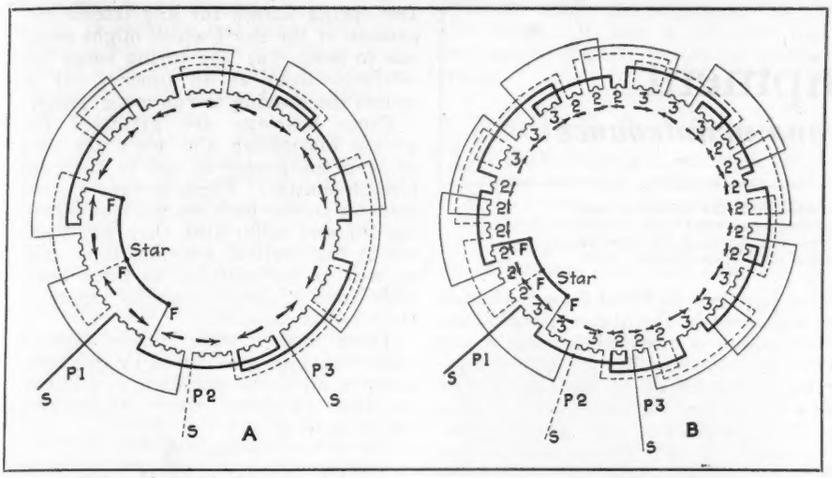


Fig. 1—The speed and horsepower of this induction motor were decreased by changing the coil grouping and number of poles.

In diagram *A* is shown the original winding of 72 coils, connected series star for six poles, equal grouping, four coils per pole-phase group. Diagram *B* shows the new ten-pole winding consisting of 72 coils with unequal grouping, connected series-star. The figures indicate the number of coils per pole-phase group.

the new chord factor was 100 per cent, the counter emf. would be (100×330) ÷79=417.7 volts, which was much lower than the impressed voltage, but it was decided to reconnect the motor.

The original winding had 72÷(3×6) =4 coils per pole-phase group, while with the new connection, this would be 72÷(3×10)=2.4. This made the new connection one of unequal groups, or numbers above and below 2.4. We decided to use 18 groups of two coils each and 12 groups of three coils each, making a total of 72 coils, which was the required number. The motor was then connected series-star, as originally, but for ten poles, and put into service. When driving the pump only, the ammeter reading was 70 amp., at 55 per cent power factor. We had no way of exactly obtaining the efficiency; so this was assumed as 87 per cent, and with this factor as a basis we figured that the pump required (0.87×70×0.55× 550×1.73)÷746=42.5 hp.

There were two agitators that required about 15 hp. to drive them; so it was decided to drive these from the pump motor lineshaft and save the cost of a 15-hp. motor. This was done and the ammeter reading increased to 85 amp. at 65 per cent power factor. Assuming the efficiency at 88 per cent, the horsepower output was (550×85× 0.65×0.88×1.73)÷746=62 hp. There was a slight unbalance of current in the different phases and the power factor of the motor was lower than it was with the original winding, but this was to be expected, since the speed was lower. As the horsepower of the motor was reduced, the carrying capacity of the windings was not considered.

This motor has been in operation for eight months, carrying its load constantly 24 hr. each day with no heating above normal and has given entire satisfaction. Diagram *B* of Fig. 1 shows the connections after the change.

The other case was that of a 10-hp., 600-r.p.m., three-phase, 60-cycle, 550-volt induction motor, which was connected by a belt to a gas blower. The speed of the blower was 950 r.p.m., and it was desired to increase the speed to 1,150 r.p.m., in order to obtain proper combustion in a sulphur burner. This meant that the motor speed would have to be about 700 r.p.m. Assisting this blower was an exhaust blower driven by a 10-hp., 1,200-r.p.m. induction motor. The latter fan was not economical, as it wasted considerable gas.

The first point considered was the power output, as the greater fan speed indicated that the horsepower of the motor would have to be increased. Theoretically speaking, a change from 600 to 720 r.p.m. would increase the motor output to (720×10)÷600=12 hp.

The next point considered was the carrying capacity of the winding. On examination it was found that the coils were wound with No. 12 d.c.c. wire and the connection of the complete winding was series-star. No. 12 d.c.c. wire has a carrying capacity of 25 amp., but the full-load current of a winding is equal to the line current divided by 1.73 and in this case equaled, 12÷1.73=6.9 amp., so that there was ample carrying capacity for the starting current even if it were four times normal full-load current. The details of the winding are shown in Fig. 2 *A*. On further investigation it was found that the stator had 108 slots and 108 coils with a pitch of 1-and-9. Full pitch would be 108÷12=9, so that the chord factor of the winding was 0.985, for 180 (deg.)÷ 9(slots)=20, and the sine of one-half of (20×8) deg. = 0.985. Connecting for 720 r.p.m. required 7,200 (alternations) ÷720=10, or a 10-pole connection. Full pitch for this connection equals 108÷ 10=10.8. This left the coils in the same slots and gave them a chord factor of 0.916 when connected for ten poles, since 180 deg.÷10.8=16.6 and the sine of one-half of (8×16.6) deg=0.916.

With the increase in speed, the generator action of the motor, with the old winding, would increase the required voltage to (720×550)÷600=660 volts, but since the chord factor was decreased from 0.985 to 0.916 the voltage would be reduced to (660×0.916)÷ 0.985=613 volts.

In connecting the winding for ten poles, unequal grouping was again encountered, since 108÷number of poles× number of phases, 108÷(10×3)=3.6; some groups would thus consist of three coils and others of four coils. Figuring the coils per pole-phase group gave 18 groups of four coils each, or 72 coils, and 12 groups of three coils each, or 36 coils, making a total of 30 groups and 108 coils. The winding was connected series-star as shown in Fig. 2*B*.

When this motor was again placed in service, the full-load speed was 690 r.p.m., while the speed of the fan was 1,140 r.p.m. The starting torque of the motor was increased. Likewise, the pressure of the gas was increased enough to enable us to dispense with the 10-hp. fan mentioned above. The full-load current taken by the motor was 14 amp. at 80 per cent power factor and with an efficiency of 88 per cent, the full-load rating was 12.5 hp.

H. E. STAFFORD.
Electrical Engineer,
Provincial Paper Mills, Ltd.,
Port Arthur, Ont., Can.

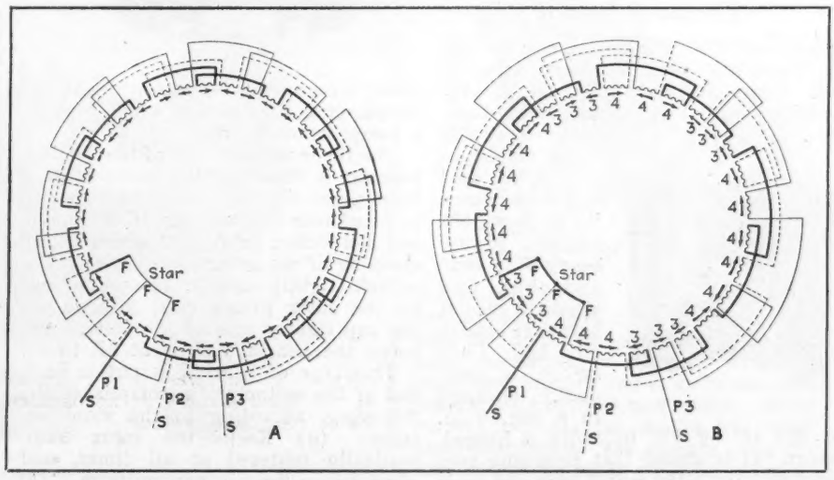


Fig 2—In this case the speed and horsepower of the motor were increased.

Diagram *A* shows the original winding of 108 coils connected series-star for 12 poles, equal grouping, three coils per pole-phase group. The motor was rewound, as shown in *B*, for ten poles, 108 coils connected series-star, unequal grouping. The figures indicate the coils per pole-phase group.

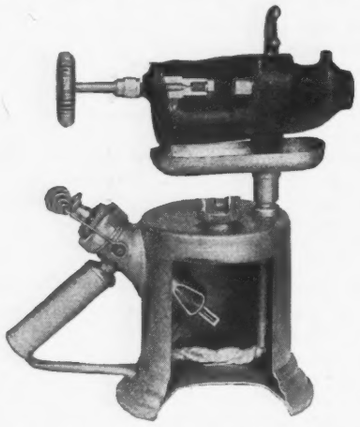
New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

New Gasoline Blowtorch

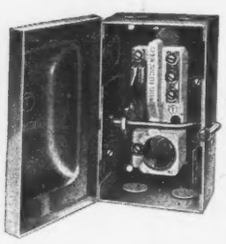
THE accompanying illustration shows the construction of the operating parts of the new Wall Dreadnaught No. 41 blowtorch. Some of the advantages claimed for this new



torch are: It can be supplied to burn kerosene or gasoline; it produces a bigger, broader flame; every time the valve is opened or closed, the orifice is automatically cleaned by a needle, which is easily removed and replaced if damaged; it is impossible to enlarge the orifice or damage the valve seat. It is also equipped with a special burner patterned after the Wall furnace burner. Other features, common to all Dreadnaughts, it is stated, include seamless steel tank with bottom and all connections brazed with hard brass spelter solder; fuel economy; long life and absolute safety. This is made by P. Wall Mfg. Co., Pittsburgh, Pa.

Single-Blade, Single-Fuse Enclosed Switch

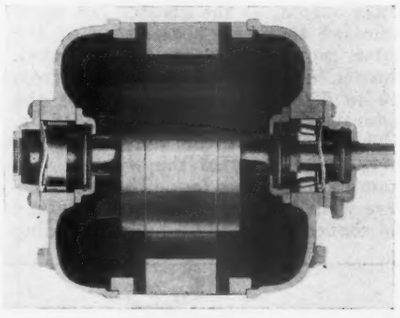
PRODUCTION is announced by The Trumbull Electric Manufacturing Co., Plainville, Conn., on the E. W. (easily wired) single-blade, single-fuse, enclosed switch which is designed to be used in places where it is now the practice to use heavy-duty snap switches and separate cut-out boxes on branch circuits. This switch is compactly enclosed in a box, 6 in. by 3$\frac{11}{16}$ in. by 3⅜ in., with a hinged cover. It is stated that removing two screws permits the switch base and operating handle to be lifted from the box as a unit, which facilitates installation. This switch is intended for use in any 125-volt, two-wire branch circuit carrying a current of 30 amp. or less, or as a single-fuse entrance switch. Some of the general uses are: starting motors up to ¼ hp.; for entrance work; for controlling heavy-duty lighting circuits; and on domestic or industrial heating devices.



This switch is totally enclosed and provided with holes in the catch for seals or padlocks. Concentric knockouts for ½-in. and ¾-in. conduits are provided in the sides, ends and back. It is stated that ample wiring space is provided on all sides and under the switch.

Automatic Rotor Recentering Bearings for Motors

TO INSURE uniform air gap in motors, the Howell Electric Motors Co., Howell, Mich., has brought out a complete line of motors with anti-friction bearings, in which, it is stated, any looseness in the bearing, caused by wear or otherwise, is instantly and automatically taken up, so as to keep the rotor of the motor continually centered with a uniform air gap. This is accomplished by the use of a Timken taper roller bearing, shimmed with a



fluted wire spring, as shown in the accompanying illustration, which acts as a compression spring.

The inner race or cone of the Timken bearing is fitted on the shaft with a light press fit. The outer race or cup is fitted into the housing of the motor end bell with a sucking fit which allows creeping of the outer race. The spring is held tightly against this outer cup by the outer grease cap; this pushes the cup tightly against the rollers and keeps the bearings tight at all times.

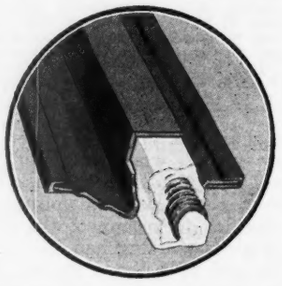
This type of bearing is put in each end of the motor and accomplishes the following, according to the manufacturer: (*a*) Keeps the rotor automatically centered at all times, and thus keeps the air gap uniform. (*b*) The spring allows for any lateral expansion of the shaft which might occur due to heat. (*c*) The spring keeps the bearings tight at all times. (*d*) It causes the bearing to run more quietly.

These bearings are arranged for grease lubrication and seals are used to keep the grease in and to keep out foreign matter. These motors can be mounted in any position, without changing the end bells; also, they will operate in the vertical position, it is said, as well as horizontally, as these bearings have a thrust capacity equal to their radial capacity.

These motors with Timken tapered roller bearings are offered by this company in all types and sizes, in addition to their regular rotor recentering sleeve bearing.

Electric Space Heater

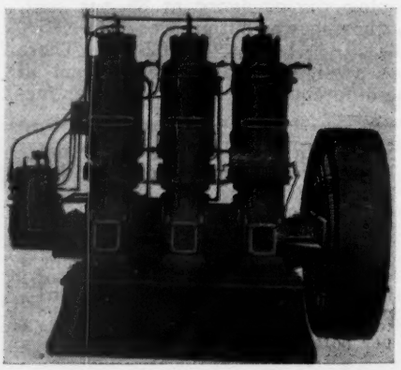
ANNOUNCEMENT is made by the Cutler-Hammer Mfg. Co., Milwaukee, Wis., of an improved design of space heater. The heating coil, as shown in the accompanying illustration,



is imbedded in a protecting and radiating material of improved refractory quality, according to the manufacturer. These heaters are 2 ft. long and may be installed singly, in pairs, or in groups. It is stated that this new type of heater is easier to install and has increased heating efficiency. This heater may be used in crane cabs, isolated watchmen's houses, garages, sprinkler system valve houses, japanning ovens and for various other purposes.

Flywheel Type Alternators for Engine Drive

THE Ideal Electric & Manufacturing Co., Mansfield, Ohio, which recently brought out a new line of motors called the "Flywheel Type," are now in a position to furnish this as an engine-type alternator or self-contained power unit. Because the



alternator is an integral part of the engine, it occupies less space than the old conventional design and does away entirely with any generator foundation and erecting, as shown in the accompanying illustration.

The manufacturer states that with the same rotor weight, the flywheel effect of the flywheel-type alternator is nearly twice that of the present-day design. If extra heavy flywheel effect is desired, the rotor can be provided with a double-rim section.

This type of alternator adapts itself admirably to the "overhung" type without auxiliary flywheel, and the problem of incorporating the necessary flywheel effect in the alternator rotor has merely become a question of bearing limitations. It is stated that the air gap is always correct and uniform and will stay so during the life of the machine. An exciter or any auxiliary machine may conveniently be belted to the flywheel rotor, thus saving an auxiliary pulley.

Electrical Test Bench

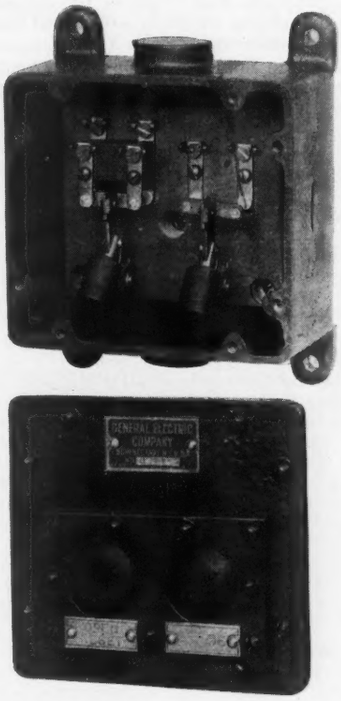
ELECTRICAL test bench illustrated is being manufactured by the Hobart Brothers Co., Canal Lock Square, Troy, Ohio, for locating troubles and testing out automobile starting motors, generators or other electrical equipment.

The test bench is equipped with a 1½-hp. Hobart, reversible, variable-speed motor. A tachometer indicates the motor speed. The set has a two-point spark gap and a rotary spark gap graduated in 360 deg. A silent flexible coupling is used between the motor and the chuck which has an adjustable flexible mounting. The vise is designed to handle all sizes and types of automotive generators, starting motors, and similar small equipment.

The switchboard is of Bakelite and the switches are all of the inclosed tumbler type. Test sockets with external leads and a condenser with in and out plugs are provided. The ammeter has a range of 30-0-30 and 600-0-600, while the voltmeter has a 0-25 range. It has a 110-volt test lamp and a complete fixture for testing torque.

Dust-Tight Push Buttons

WHERE dust-tight, enclosed, magnetic starting switches are used on a.c. circuits, a specially designed push-button station is often employed. The device shown in the accompanying illustration was originally designed by



the General Electric Co., Schenectady, N. Y., for marine use, and the push button was mounted under partial cover on deck where it would occasionally be subjected to a spray of water. To obtain the necessary protection, a cast-iron case is used with a flexible leather gasket over the push buttons.

Each button is operated by pressing on the leather directly over it. The leather is very flexible and may be kept in that condition by occasional applications of neatsfoot oil. The push-button station can be mounted either vertically or horizontally and is dust-tight.

New Fire Extinguisher

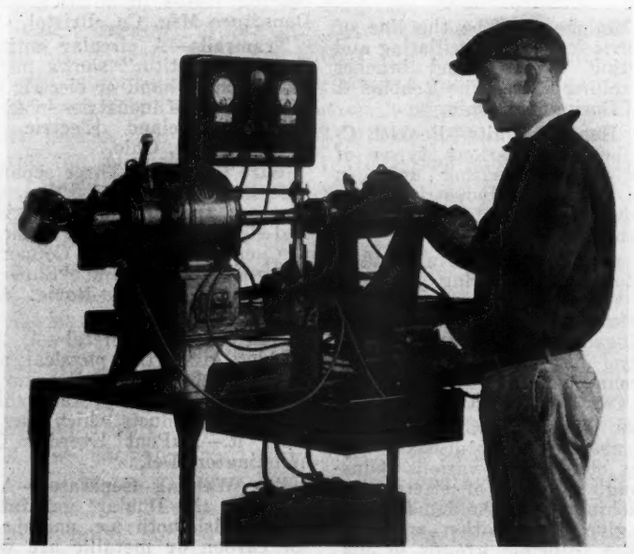
THE Rego Fire Stopper, manufactured by the Bastian-Blessing Co., 240 East Ontario St., Chicago, Ill., is intended for use in garages, power stations, industrial plants or private buildings.

This type of extinguisher is composed essentially of two parts: a cylinder to hold compressed carbonic acid gas and a cone to be filled with powder. In use, the valve in the tank is opened as much as may be necessary. The escape of the gas creates a whirling action in the cone and projects the powder through the nozzle in a stream that has a range of about 25 ft., according to the manufacturer.

The carbonic acid gas has a smothering effect on the flame, it is stated, while the powder, when it comes in contact with the flame, decomposes into carbonic acid gas and water or steam, and any remaining powder will blanket the flame in much the same manner as would a similar amount of sand. Tests are said to have shown that the powder is a non-conductor of electricity and can be used against electric fires on circuits up to 160,000 volts without danger to the operator.

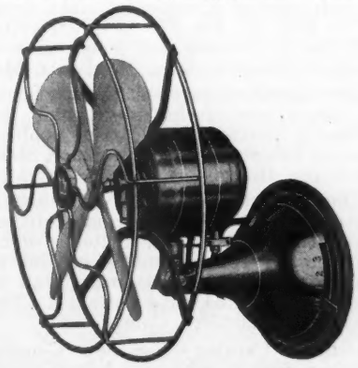
Advantages claimed for the extinguisher are that it can be stopped at any time while in operation and can be used again without recharging and leaves no injurious by-products.

The cone has a capacity of 2 gal. or 17 lb. of powder and the apparatus weighs 32 lb. when charged.



Oscillating Bracket Fan

THE accompanying illustration shows a Model 46, 10-in. a.c. oscillating fan announced for 1926 by The Robbins & Myers Co., Springfield, Ohio. This is a four-blade, three-speed fan with a



drawn-steel frame. The motor is of the induction type for 50 or 60 cycles only and of the shaded-pole type. The gear mechanism is integral with the rear head bracket and is fully enclosed within a removable end cover. It is stated that this fan makes five complete oscillations per minute over 75 deg. or can be made non-oscillating.

Trade Literature
you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Arc Welding Supplies—Section 1611 is an 8-page catalog covering the line of Lincoln arc welding supplies, which include cables, shields, welding electrodes, aprons, gloves, brushes, electrode holders, and other accessories used in repair, structural, or production work.—The Lincoln Electric Co., Cleveland, Ohio.

Worm Gearing—Bulletin 105 gives interesting data on standard worm mountings on various centers as well as gear ratios available on those centers, dimensions of standard gears and flanged gear rims, as well as several applications of Cleveland worms and gears and speed-reduction units.—The Cleveland Worm & Gear Co., 3258 E. 80th St., Cleveland, Ohio.

Crane and Derrick Hoists and Drives—Catalog 84 illustrates and describes the line of Shepard crane and derrick hoists, back-geared electric motors, speed reducers, and industrial, contractors' and hauling winches. Numerous installations are illustrated.—Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.

Repair-Shop Equipment—A 14-page booklet describes various pieces of repair-shop equipment particularly adaptable to automotive and other light electrical repair work.—David W. Onan, 43-51 Royalston Ave., Minneapolis, Minn.

Speed Reducers—A 16-page bulletin illustrates with cross-section views and describes the DeLaval line of worm and single and double helical speed reducers.—DeLaval Steam Turbine Co., Trenton, N. J.

Slip-Ring Induction Motors—Bulletin 137 illustrates the construction, describes the operation, and shows by charts the operating characteristics of the Wagner wound-rotor, slip-ring polyphase motors, which are built for two- or three-phase circuits in sizes from ¼ to 300 hp., for 110 to 2,300 volts, and for all commercial frequencies.—Wagner Electric Corp., St. Louis, Mo.

Non-Metallic Gears—A 24-page booklet gives engineering data and describes a number of industrial applications of Celoron gears.—Diamond State Fibre Co., Bridgeport, Pa.

Time Switches—Catalog 4, Section 1, describes the electric, motor-driven States time and distance switches which may be set for automatic control of the operation of any electric circuit or device on a fixed time schedule.—The States Co., Hartford, Conn.

General Catalog—The new General Catalog, 6001 B, which is issued every two years, contains 1,100 8-in. by 10½-in. pages with over 3,200 illustrations. The catalog is thumb-indexed into 16 sections as follows: generation, wire and cable, distribution transformers, arresters, voltage regulators, switchboards and accessories, meters and instruments, motors, motor applications, industrial control, railway, lighting, industrial heating, and miscellaneous. Products are also indexed by subjects and by catalog numbers.—General Electric Co., Schenectady, N. Y.

Gasoline Soldering Irons—A circular describes the gasoline Ever-Hot combination branding and soldering blowtorch and various types of tips which may be used in connection with it.—Combination Blow Torch Mfg. Co., 2809 W. Van Buren St., Chicago, Ill.

Lubrication—A monthly bulletin under the above heading discusses the selection and use of lubricants for various types of equipment. For example, the December, 1925, issue was on "Lubrication of Materials Handling Equipment."—The Texas Co., Dept. H, 17 Battery Pl., New York City.

Manual Controllers—Bulletin 100 describes the new Clark manual controller which is of the faceplate type, built for heavy-duty service, and is suitable for electric traveling cranes, charging machines, mill tables, or any other applications where reversing of the motor is necessary and where hand operation is suitable. This is made in ratings of from 1 to 25 hp. at 110 volts, and proportionate ranges for other voltages.—The Clark Controller Co., Cleveland, Ohio.

Countershaft Bearings—A folder describes the use and life of the Arguto oilless bearings on countershafts.—Arguto Oilless Bearing Co., Wayne Junction, Philadelphia, Pa.

Induction Motor—A 26-page catalog describes the Linc-Weld induction motor, its construction and special features. This motor is made of steel parts welded together and is built for standard a.-c. voltages from 110 to 2,300 volts, for two- or three-phase, and 25, 30, 40, 50 and 60 cycles in sizes from 1 to 500 hp.—The Lincoln Electric Co., Cleveland, Ohio.

Fans—Catalogs describe the line of R & M electric fans, both oscillating and non-oscillating in wall and bracket types and ceiling type.—The Robbins & Myers Co., Springfield, Ohio.

Electric Heating Units—Booklet C-100 describes the various types of Chromalox electric heating units in convenient forms for industrial heating.—Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa.

Conduit and Fittings—Catalog 10 is both a catalog and a wiring guide for the use of Wiremold conduit system for surface wiring. The various fittings are cataloged and illustrated and sketches and diagrams show how they may be connected up.—The American Wiremold Co., Hartford, Conn.

Materials Handling—Circular 7378 under the above heading discusses the advantages obtained in various industries through the use of electrically-driven machinery for the handling of material, gives information and data covering the principle groups of materials handling devices, and describes Westinghouse electrical equipment developed especially for materials handling machinery.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Speed Reducer—A circular describes the Lipe speed reducer, which is a ball-bearing, planetary unit with a flexible coupling built in on the low-speed shaft. These reducer units are built in two types for reduction from 4 : 1 to 100 : 1 and from 48 : 1 to 7,000 : 1 up to maximum ratings of 500 hp.—W. C. Lipe, Inc., 208 S. Geddes St., Syracuse, N. Y.

Electric Industrial Trucks—A 40-page bulletin illustrates, describes and gives specifications for various types of Crescent trucks, tractors and other special storage-battery equipment. Numerous applications in different plants are illustrated.—The Crescent Truck Co., Lebanon, Pa.

Non-Metallic Gears—A booklet describes and discusses Formica silent gears, gives data on the horsepower ratings, and instructions for their use.—The Formica Insulation Co., Cincinnati, Ohio.

Across-the-Line Switch—A circular illustrates a number of applications of the J-1552 across-the-line starter for a.c. motors, lists the advantages claimed, and shows the construction.—Allen-Bradley Co., Milwaukee, Wis.

Hand Lift-Trucks—The 16-page Bulletin 101 describes Models F and G Barrett hand lift-trucks and shows applications in a wide variety of industries.—Barrett-Cravens Co., 1328 W. Monroe St., Chicago, Ill.

Flexible Couplings—A folder describes the Falk-Bibby flexible couplings and illustrates their operation under light and normal loads and severe overloads. This coupling is manufactured in capacities ranging from ⅛ to 20,000 hp. at 100 r.p.m.—The Falk Corp., Milwaukee, Wis.

Hand Lift Truck—A circular describes the new Cowan Blue Streak self-loading hand lift truck which has roller-bearing wheels with Alemite lubrication. This type is built in various sizes of platforms and diameter of wheels, but only in 2,000-lb. capacity.—Cowan Truck Co., Holyoke, Mass.

Ball-Bearing Motors—A circular gives some interesting figures stating how an annual saving of 20.9 per cent on the investment was made on a ball-bearing motor installation.—The New Departure Mfg. Co., Bristol, Conn.

Tramrails—A circular entitled "Mr. Keen Kompetitor" shows installations of Cleveland hand or electric tramrails in a variety of industries in 42 different plants.—Cleveland Electric Tramrail Co., Wickliffe, Ohio.

Wire Catalogs—Three separate catalogs illustrate and describe, give ratings and specifications of various types and sizes of Rome wire. These catalogs are entitled, "Bare Copper Wire," "Magnet Wire," and "Super Service Cord and Cable."—Rome Wire Co., Rome, N. Y.

Non-Corrosive Metal—A 40-page booklet gives the physical properties and characteristics of Everdur, a corrosion-resistant alloy, and illustrates numerous products which may be made from it.—DuPont Everdur Co., Inc., Wilmington, Del.

Arc Welding Generator—A circular describes the Dualarc generator which can furnish both a.c. and d.c. current for carbon or metallic arc welding.—Electric Arc Cutting & Welding Co., 152-156 Jelliff Ave., Newark, N. J.